THE ENGINEER'S

COMMON-PLACE BOOK

OF

PRACTICAL REFERENCE.

BY WILLIAM TEMPLETON.

With Four Lithographic Illustrations.

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Author of "The Engineer's Common-place *Book of Practical Reference."*

FIFTH EDITION.

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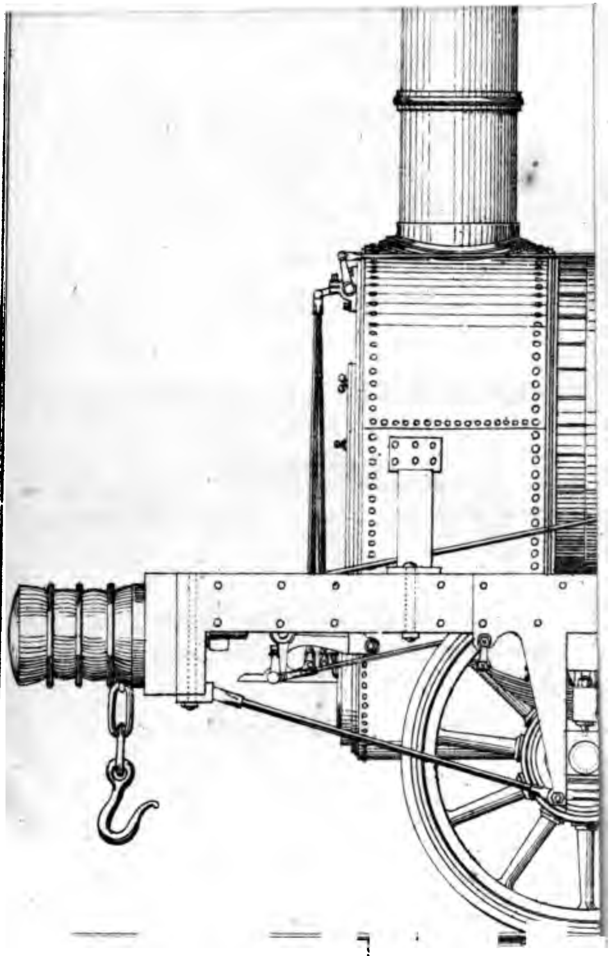


THE

ENGINEER'S COMMON-PLACE BOOK

OF

PRACTICAL REFERENCE,

CONSISTING OF

PRACTICAL RULES AND TABLES

ADAPTED TO

LAND, MARINE,

AND

LOCOMOTIVE STEAM-ENGINES.

TO WHICH IS ADDED,
SQUARE AND CUBE ROOTS OF NUMBERS; AREAS AND CIRCUMFERENCES OF CIRCLES; SUPERFICIES AND SOLIDITIES OF SPHERES,
&c. &c. &c.

BY WILLIAM TEMPLETON,
Author of "The Millwright and Engineer's Pocket Companion."

WITH LITHOGRAPHIC ILLUSTRATIONS.

LONDON:
PUBLISHED BY SIMPKIN, MARSHALL, AND CO., STATIONERS'-HALL-COURT; SOLD ALSO BY G. HEBERT, 88, CHEAPSIDE, LONDON; EGERTON SMITH AND CO., LIVERPOOL; J. AND J. THOMSON; MANCHESTER; W. CURRY, JUN., AND CO., DUBLIN; BLACK AND CO., EDINBURGH; AND BY ALL BOOKSELLERS.

1839

ENTERED AT STATIONERS'-HALL.

ADVERTISEMENT.

Popular works upon the steam-engine have become so numerous of late, that it might be supposed any attempt at farther illustration would only be an unnecessary repetition of former matter; and that, if possessed of any one work upon the subject, another is not required. Such, however, is not the case, for as improvements advance so must corresponding calculations follow, deduced from those improvements, which cannot otherwise be so effectually obtained; because any rule to be made practically useful must be divested as much as possible of theory, and the more explicit a rule is the more generally useful it will prove to the practical engineer.

Having, in the course of my own practical employment, been frequently in want of ready practical rules connected with the steam-engine, and as often disappointed, after referring to works in which the required information might be expected, I was, in consequence, compelled to form rules from those engines which I found doing the greatest amount of duty at the least possible expense: hence, the following pages will be found chiefly to consist of those practical rules connected with the steam-engine in most of its various departments of application, and entirely divested of all speculative matter, by which the work might have been

very considerably increased in bulk, but, in proportion, its value as greatly diminished.

I also found, in practice, that rules were much easier obtained and remembered when in the algebraic than in the arithmetical form ; and knowing that it is now becoming more familiar as a science of numbers, I have been induced to give the greater part of the rules in the one form, and the examples in the other, so that the work might be rendered, not only a book of daily reference upon the steam-engine, but also the means of acquiring mathematical knowledge, as applicable to any other subject in which demonstration is required.

In the locomotive department I have been rather explicit, as it is the latest application of the steam-engine, and also my present practical employment, but I trust the work will be found generally useful, and particularly to those connected with either stationary, marine, or locomotive steam engines.

Leeds and Selby Railway,
Leeds, April, 1839.

INDEX.

MISCELLANIES.

ERRATUM.

By mistake, the tables at the end of the work have been erroneously paged; but the error is immaterial as the tables themselves are consecutively numbered, except Table IX, which is numbered Table II.

THE PRACTICAL

ENGINEER'S COMMON-PLACE BOOK, &c.

ALGEBRAIC SIGNS,

AS APPLIED IN MECHANICAL CALCULATIONS.

$=$ Sign of Equality, and signifies equal to ...... as 3 added to $4 = 7$.

$+$ Addition .... plus, or more............... $5 + 3 = 8$.

$-$ Subtraction ....minus, or less............... $8 - 3 = 5$.

$\times$ Multiplication ....multiplied by............ $8 \times 3 = 24$.

$\div$ Division ....divided by ...$24 \div 4 = 6$, or $\frac{24}{4} = 6$.

$: :: :$ Proportion .... that 2 is to 3 as 4 is to 6.

$\sqrt{\ }$ Square Root, $\sqrt[3]{\ }$ Cube Root ......Evolution, or the extraction of roots, thus, $\sqrt{64} = 8$, and $\sqrt[3]{64} = 4$.

4^2 to be squared, 4^3 to be cubed ......Involution, or the raising of powers, thus, $4^2 = 16$, and $4^3 = 64$.

$\overline{3 + 5} \times 4 = 32$......................that 3 plus 5 multiplied by $4 = 32$.

$\sqrt{5^2 - 3^2} = 4$... 5 squared, minus 3 squared, the square root of the remainder $= 4$.

$\frac{\sqrt[3]{20 \times 12}}{30} = 2$...20 multiplied by 12, and divided by 30, the cube root of the quotient $= 2$.

$\frac{\overline{\overline{24 \times 6} + \overline{12 \times 3}} \times 4}{12} = 60$...24 multiplied by 6, and 12 multiplied by 3, added together, multiplied by 4 and divided by 12, the quotient $= 60$.

$\frac{A\,V\,Q}{n\,l} = d$...that A, V, and Q, multiplied together, and divided by n multiplied by l, the quotient $= d$.

$\frac{\overline{P - p} \times d}{W} = D$...P minus p multiplied by d, and divided by $W = D$

$S = \frac{V\,[\,\overline{(q\,M + F)\,D} + \overline{p\,d^2\,l}\,]}{m\,P\,D}$...$q$ multiplied by M, plus F, and multiplied by D, plus p, multiplied by d squared, and by l, the whole sum multiplied by V, and divided by the product of m P D, the quotient $=$ S.

IMPERIAL STANDARD MEASURES.

I. MEASURE OF LENGTH.

Inches.					
12	1 foot.				
36	3	1 yard.			
198	16½......	5½......	1 pole or perch.		
7920	660	220	40	1 furlong.	
63360	5280	1760	320	8	1 mile.

The French metre or standard measure of length = 39.371 in.

SPECIAL MEASURES OF LENGTH.

Nautical Measure.		*Land Measure.*	
1 nautical mile	= 6082.66 ft.	7.92 inches	= 1 link.
3 miles	= 1 league.	100 links	= 1 chain.
20 leagues	= 1 degree.	80 chains	= 1 mile.
360 degrees	= earth's cir.	69.121 miles	= 1 geo. deg.

6 feet = 1 fathom, used in measuring ropes, chains, &c.

A Table of the common fractional parts of an inch and a foot, with their corresponding decimals.

Fractions of an inch.	Decimals.	Fractions of an inch.	Decimals.	Fractions of a foot or inches.	Decimals.
$\frac{7}{8}$ & $\frac{3}{32}$	= .96875	$\frac{3}{8}$ & $\frac{3}{32}$	= .46875	11	= .9166
$\frac{7}{8}$ & $\frac{1}{16}$	= .9375	$\frac{3}{8}$ & $\frac{1}{16}$	= .4375	10	= .8333
$\frac{7}{8}$ & $\frac{1}{32}$	= .90625	$\frac{3}{8}$ & $\frac{1}{32}$	= .40625	9	= .75
$\frac{7}{8}$	= .875	$\frac{3}{8}$	= .375	8	= .6666
$\frac{3}{4}$ & $\frac{3}{32}$	= .84375	$\frac{1}{4}$ & $\frac{3}{32}$	= .34375	7	= .5833
$\frac{3}{4}$ & $\frac{1}{16}$	= .8125	$\frac{1}{4}$ & $\frac{1}{16}$	= .3125	6	= .5
$\frac{3}{4}$ & $\frac{1}{32}$	= .78125	$\frac{1}{4}$ & $\frac{1}{32}$	= .28125	5	= .4166
$\frac{3}{4}$	= .75	$\frac{1}{4}$	= .25	4	= .3333
$\frac{5}{8}$ & $\frac{3}{32}$	= .71875	$\frac{1}{8}$ & $\frac{3}{32}$	= .21875	3	= .25
$\frac{5}{8}$ & $\frac{1}{16}$	= .6875	$\frac{1}{8}$ & $\frac{1}{16}$	= .1875	2	= .1666
$\frac{5}{8}$ & $\frac{1}{32}$	= .65625	$\frac{1}{8}$ & $\frac{1}{32}$	= .15625	1	= .0833
$\frac{5}{8}$	= .625	$\frac{1}{8}$	= .125	$\frac{7}{8}$	= .07291
$\frac{1}{2}$ & $\frac{3}{32}$	= .59375	— $\frac{3}{32}$	= .09375	$\frac{3}{4}$	= .0625
$\frac{1}{2}$ & $\frac{1}{16}$	= .5625	— $\frac{1}{16}$	= .0625	$\frac{5}{8}$	= .0528
$\frac{1}{2}$ & $\frac{1}{32}$	= .53125	— $\frac{1}{32}$	= .03125	$\frac{1}{2}$	= .04166
$\frac{1}{2}$	= .5			$\frac{3}{8}$	= .03125
				$\frac{1}{4}$	= .02083
				$\frac{1}{8}$	= .01041

2. MEASURE OF SURFACE.

Inches.					
144	1 square foot.				
1296	9	1 square yard.			
39204	$272\frac{1}{4}$......	$30\frac{1}{4}$......	1 square pole.		
1568160	10890	1210	40	1 rood.	
6272640	43560	4840	160	4	1 acre.

SPECIAL MEASURES OF SURFACE.

Land Measure.

62.7264 square inches = 1 square link,
10000 „ = 1 „ chain, and
10 square chains = 1 acre.

3. MEASURES OF CAPACITY.

General Measure of Solidity.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.
42 cubic feet = 1 ton of shipping.

4. IMPERIAL GALLON MEASURE FOR LIQUIDS, CORN, &c.

Cubic inches.	Water lbs. av.							
8.665	$\frac{5}{16}$	1 gill.						
34.659	$1\frac{1}{4}$	4 ...	1 pint.					
69.318	$2\frac{1}{2}$	8 ...	2 ...	1 quart.				
277.274	10	32 ...	8 ...	4 ...	1 gallon.			
554.548	20	64 ...	16 ...	8 ...	2 ...	1 peck.		
2218.19	80	256 ...	64 ...	32 ...	8 ...	4 ...	1 bushel.	
17745.5	640	2048 ...	512 ...	256 ...	64 ...	32 ...	8 ...	1 qrtr.

The peck, bushel, and quarter, are used for dry goods only.

1 gallon of sea water = 10.32 lbs. avs.
1 „ oil = 9.32 „
1 „ proof spirits = 9.3 „
1 bushel of wheat = 60 „
1 „ barley = 47 „
1 „ oats = 38 „

The old ale gallon contained 282 cubic inches; and
The old wine gallon 231.

The French litre, or standard measure of capacity for liquids, contains 61.028 cubic inches, or about .453 of imperial gallon.

5. IMPERIAL MEASURE OF CAPACITY FOR COALS, CULM, LIME, FRUIT, &c.

351.9375 cubic inches	1 gallon.				
703.875	2 ...	1 peck.			
2815.5	8 ...	4 ...	1 bushel.		
4.888 cubic feet	24 ...	12 ...	3 ...	1 sack.	
58.656	288 ...	144 ...	36 ...	12 ...	1 chaldron.

In and about London coals are sold by the cwt., ton, &c. but in Yorkshire, and many other places, they are sold by the bag, and estimated as follows :—

1 bag = 2 bushels, and weighs about 140lbs.
16 bags = 1 ton, and 24 bags = 1 chaldron, or 30 cwt.

A keel of coals at Newcastle is 21 tons 4 cwt., and a chaldron 53 cwt. A chaldron of coals in London is 28½ cwt.

6. AVOIRDUPOIS WEIGHT.

Troy Grains.						
27.34375	1 dram.					
437.5	16 ...	1 ounce.				
7000	256 ...	16 ...	1 lb.			
98000	3584 ...	224 ...	14 ...	1 stone.		
196000	7168 ...	448 ...	28 ...	2 ...	1 quarter.	
784000	28672 ...	1792 ...	112 ...	8 ...	4 ...	1 cwt.
15680000	573440 ...	35840 ...	2240 ...	160 ...	80 ...	20 ... 1 ton

The French gramme, or standard measure of weight, equal 15.434 troy grains, and the kilogramme 2.20486 lbs. avoir.

About	426	cubic inches	of cast iron	= 1 cwt.
	8520	„	or	
nearly	5	cubic feet		= 1 ton.
	13	„	of stone	= 1 ton.
	23	„	sand	= 1 ton.
	29	„	coal	= 1 ton.
	38	„	tallow	= 1 ton.
	39	„	oil	= 1 ton.
	40	„	timber	= 1 ton.
	36	„	com. water	= 1 ton.
	35	„	sea water	= 1 ton.

Table of Specific Gravities.

NAMES OF BODIES.	Weight of a cubic foot in lbs.	Weight of a cubic in. in ounces.	Number of cubic inches in a lb.	Weight of a cubic inch in lbs.
Copper, cast	549.25	5.086	3.146	.3178
Copper, sheet	557.18	5.159	3.103	.3225
Brass, cast	524.75	4.852	3.223	.3037
Iron, cast	454.43	4.203	3.802	.263
Iron, bar	476.93	4.410	3.623	.276
Lead	709.00	6.456	2.437	.4103
Steel, soft	489.56	4.527	3.530	.2833
Steel, hard	488.50	4.517	3.537	.2827
Zinc, cast	449.37	4.156	3.845	.26
Tin, cast	455.75	4.215	3.790	.2636
Bismuth	619.50	5.710	2.789	.3585
Gun metal	549.00	5.077	3.147	.3177
Sand	95.00	.878	18.190	.055
Coal	78.12	.722	22.120	.0452
Brick	125.00	1.156	13.824	.0723
Stone, paving	151.00	1.396	11.443	.0873
Marble	171.37	1.585	10.083	.0991
Glass	180.00	1.664	9.600	.1042
Tallow	59.06	.546	29.258	.0342
Cork	15.00	.138	115.200	.0087
Oak	60.62	.561	28.505	.0351
Pine, pitch	41.25	.382	41.890	.024
Ash	47.50	.440	36.370	.0275
Spirits, proof	57.93	.536	29.828	.0335
Mercury	848.00	7.851	2.037	.4908

A Table of the specific gravity of water at different temperatures, that at 62 being taken as unity.

70°F.	.99913	52°F.	1.00076
68	.99936	50	1.00087
66	.99958	48	1.00095
64	.99980	46	1.00102
62	1.	44	1.00107
58	1.00035	42	1.00111
56	1.00050	40	1.00113
54	1.00064	38	1.00115

Note. The difference of temperatures between 62° and 42°, where water attains its greatest density, will vary the bulk of a gallon rather less than the third of a cubic inch.

WATER.

Water in an aëriform state constitutes the moving power in a steam-engine; consequently, a knowledge of its *chemical* and *mechanical* properties is of decided importance to the practical engineer.

WATER AND ITS ELEMENTS.

Water, or oxide of hydrogen, is so slightly compressible that it may be said to be an *incompressible fluid body*, composed of two elementary bodies, *oxygen* and *hydrogen*, in the following proportions:—

	WEIGHT.	BULK.
Ogygen	8	1
Hydrogen	1	2
Equivalents ..	9	3

Or one cubic inch consists of

	GRAINS.	CUBIC INCHES.
Oxygen..........	224.46	662
Hydrogen	28.06	1325
	252.52	1987

Water, when pure, is transparent, colourless, tasteless, inodorous, and not liable to spontaneous change; liquid at the common temperature of our atmosphere; assuming a solid form at 32° Faht., and a gaseous state at 212°, but returning unaltered to its liquid state on resuming any degree of heat between these points; dissolves numerous vegetable, animal, and mineral substances; is decomposed in many cases of chemical action, affording oxygen or hydrogen to the substances which affect it.

Clean iron and zinc at a red heat possess the property of decomposing water when in the state of highly-rarefied steam;—the oxygen uniting with the metal, a solid metallic crust is formed on the surface, and the hydrogen

set at liberty; one volume of oxygen, or from five to six of atmospheric air, combined with two of hydrogen, render the mixture inflammable, and on the approach of a flame, red-hot iron, or the electric spark, the whole is kindled at the same instant, a flash of light passes through the mixture, followed by a violent explosion, the result of which is steam at 212° Faht., and ultimately pure water.

But water, as it exists in nature, contains various saline or earthy matters, as sulphate of soda, muriate of lime, muriate of magnesia, carbonate of lime, oxide of iron, &c., which it may have accumulated in flowing through the different strata of rocks and minerals,—constituting mineral or hard water, and rendering it very unsuitable for the purposes of a steam-engine. Rain and snow waters are the purest natural waters we possess, and are generally employed as the standard of comparison for the densities of other bodies.

Specific gravity of pure rain water = 1, or one cubic foot at a mean temperature of the atmosphere = 1000 ounces.

Ten pounds of rain or distilled water, at 62° Faht., equal the standard gallon, or measure of capacity.

And one cubic inch, at 62°Faht. = 252.458 grains.

Mineral waters of every description are more or less injurious to a boiler; and, unless very frequently changed, become in a state of saturated solution, in consequence of which earthy matters are deposited, and an incrustation formed on the surface of the iron, preventing the free passage of caloric; hence, the plates get red hot, and render the boiler in danger of being destroyed.

Mineral waters are generally divided into four classes, namely, the *acidulous*, the *sulphureous*, *chalybeate*, and *saline*.

Acidulous waters contain carbonic acid in its free state, or in combination in excess with a base; also, very frequently muriate of soda, and some of the earthy

carbonates; however, it is the free carbonic acid that imparts to them their particular properties. These waters are easily distinguished by their slightly acid taste, and sparkling appearance when poured from one vessel to another, both of which properties they lose by boiling, or standing exposed to the air for any short length of time.

Sulphureous waters contain sulphuretted hydrogen, also alkaline, earthy sulphates, and muriates; they are very readily distinguished by their odour, and by causing a piece of silver, when immersed in them, to acquire a dark colour.

Chalybeate waters are those which have iron as an ingredient; they are known by their peculiar taste, and by their becoming black when mixed with an infusion of nutgalls: but they are of different kinds; sometimes the iron is combined with sulphuric acid,—more frequently it is in union with carbonic acid.

Saline waters are those which contain the saline ingredients generally found in mineral waters, but which have not carbonic acid in excess, and are free from sulphuretted hydrogen and iron, or contain them in very trifling quantities. Saline waters may be subdivided into four kinds, namely,—alkaline waters, or those which contain alkali in its free stàte, or combined with carbonic acid, and which render the vegetable blues green; hard waters, or those which contain carbonate or sulphate of lime; salt waters, or those in which muriate of soda abounds; purgative waters, or those which contain principally sulphate of magnesia.

To acquire at once a general knowledge of the properties of any water, the following experiments may be tried:

1. Evaporate a drop on a flat slip of glass, holding it before the fire, or above a small lamp or candle. Small rings only appear where the water rested, if it contained a minute quantity of foreign matter; but a crust if it be loaded with saline or earthy matter, and is an ochry tint if iron be present.

2. Pour some of the water into a wine glass, and add a solution of litmus; it will be reddened if any acid matter be present.

3. Mix another portion with a little soap; a curdy matter appears if it abound with earthy matter.

Sea water contains of saline and earthy matter in every 100 parts,

Common salt	2.66
Sulphate of soda	.466
Muriate of lime	.199
Muriate of magnesia	.991
	4.316 parts of

saline and earthy matter. Average specific gravity 1028. Hence the necessity of frequently renewing the water in marine engine boilers at sea, by the usual process of *blowing out;* that is, by a little extra feed the boilers are allowed to fill, say, from four to six inches above the regular height, and the overcharged water blown out by the force of the steam, through a cock in the bottom of the boiler, about once every two hours.

I may here be allowed to observe, that Hall's Patent Condensers must be of considerable benefit to marine boilers on long voyages, not only from the saving of the boilers, but from the saving of fuel, if the distilling apparatus can be kept in proper condition, so as to supply sufficiently the unavoidable waste, and the tubes in the condenser kept tight, so as to prevent the sea water mingling with the condensed vapour, for fresh water boils at 212° Faht., and water saturated with salt at 224°.

MECHANICAL PROPERTIES OF WATER.

1. Fluid bodies in general exert an equal force or pressure in every direction, namely, upwards, downwards, sideways, and oblique, and fluids always tend to a level; hence, any quantity of water, however small, may be made to balance and support any quantity, however large.

2. The weight of water, or any other fluid body, is as the quantity; but the pressure is as the perpendicular height.

3. The pressure on the sides of any vessel containing a fluid is equal to the length of the side multiplied by half the square of the depth.

4. The centre of pressure, and also the centre of percussion, in a fluid, is two-thirds of the depth from the surface.

5. The quantity of water discharged through an orifice in equal times, but under different heads, are nearly as the corresponding heights of the different heads of water; hence,

$$\frac{\text{The square root of the depth in feet} \times \text{by the falling surface in inches}}{\text{Area of the orifice} \times 3.7} =$$

the time required in seconds.

Maximum density of water 42° Faht.
Freezing point 32° Faht., at which point it has expanded $\frac{1}{17}$th of its original bulk.

62.5 lbs. avoirdupois	=	the weight of 1 cubic foot.
.03617	=	1 „ inch.
.434	=	1 lineal ft. 1 in. sq.
49.1	=	1 cylindrical foot.
.02842	=	1 „ inch.
.341	=	1 lin. ft. 1 in. dia.
11.2 imperial gallons	=	1 cwt.
224.	=	1 ton.
1.8 cubic feet	=	1 cwt.
35.84	=	1 ton.
1 cubic foot of water	=	$6\frac{1}{4}$ imperial gallons, and
1 cylindrical foot	=	about 5.

$$\left.\begin{array}{l}\text{The content of any vessel in cubic feet} \times \text{by } 6.232 \\ \text{„ „ inches} \times \text{by } .003607\end{array}\right\} = \text{imperial gallons.}$$

$$\frac{\text{Any number of imperial gallons}}{\text{Any two dimensions of a cistern in feet} \times \text{by } 6.232} = \text{the}$$
third dimension in feet.

$$\frac{\text{Any number of imperial gallons}}{\text{Any two dimensions of a cistern in inches} \times \text{by } .003607}$$
$=$the third dimension in inches.

$$\left.\begin{array}{l} \text{The length of a cylinder in feet} \times \text{by the} \\ \text{square of the diameter in feet, and by } 4.895\ldots \\ \text{The length of a cylinder in feet} \times \text{by the} \\ \text{square of the diameter in inches and by } .034 \\ \text{The length of a cylinder in inches} \times \text{by the} \\ \text{sqr. of the diameter in inches and by } .002832 \end{array}\right\} = \begin{array}{l}\text{Imp.} \\ \text{gallons.}\end{array}$$

$$\sqrt{\frac{\text{any number of gallons a cylinder is required to contain} \times \text{by } 354}{\text{by the length in inches}}} =$$
the diameter of the cylinder in inches.

$$\frac{\text{any number of gallons a cylinder is required to contain} \times \text{by } 354}{\text{by the square of the diameter in inches}} =$$
the length of the cylinder in inches.

The cube of the diameter of a sphere in inches $\times$ by .001888 $=$ imperial gallons.

The velocity of water in feet per minute $\times$ by the square of a pump's diameter in inches, and by .034 $=$ imperial gallons discharged per minute.

The velocity of water in feet per minute $\times$ by the square of a pump's diameter in inches, and by .0005454 $=$ cubic feet discharged per minute.

STEAM.

Steam, or water in the state of vapour, is an elastic gaseous body, composed of water combined with caloric, or the matter of heat; transparent and colourless until it comes in contact with the atmosphere, it then assumes a dense white mass, and ultimately pure water.

Steam ascends from water at 212° Faht. equal to 14.7 lbs. avoirdupois per square inch, or the pressure of the atmosphere, generally termed one atmosphere, one cubic inch of water producing about one cubic foot of steam; but any additional pressure requires an elevation of temperature, and an increase of water, as in the following table:—

Atmospheres.	Lbs. per square inch above the Atmosphere.	Temperature in degrees of Faht.	Volume of Steam, Water being 1.	Cubic Inches of Water in a Cubic Foot of Steam.	Elastic Force in Inches of Mercury.	Elastic Force in Feet of Water.
1.19	2.5	220F	1496	1.14	5.15	5.76
1.22	3	222	1453	1.18	6.18	6.91
1.29	4	225	1366	1.25	8.24	9.22
1.36	5	228	1282	1.33	10.3	11.52
1.70	10	240	1044	1.64	20.6	23.05
2.04	15	251	883	1.93	30.9	34.57
2.38	20	260	767	2.23	41.2	46.10
2.72	25	268	678	2.52	51.5	57.62
3.06	30	275	609	2.81	61.8	69.15
3.40	35	282	553	3.09	72.1	80.67
3.74	40	288	506	3.38	82.4	92.20
4.08	45	294	468	3.66	92.7	103.72
4.42	50	299	435	3.93	103.0	115.25
4.76	55	304	407	4.20	113.3	126.77
5.10	60	309	382	4.48	123.6	138.30

Steam is produced from water at 212° Faht. as before observed, equal to the pressure of the atmosphere, or about 14.7 lbs. avoirdupois per square inch, and, under such circumstances, cannot attain either a greater higher temperature; but let the water be atmospheric pressure, and the boiler made

so tight that steam cannot escape, the fire being still continued, the water will imbibe caloric until the steam becomes so strong as to tear the boiler to pieces; hence the necessity of a

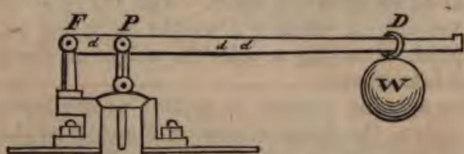
SAFETY VALVE.

A safety valve ought to contain at least *one* circular inch for every 14 square feet of generating surface contained in the boiler. Or, Multiply the number of square feet of fire or furnace bar by .75, and the square root of the product equal the safety valve's diameter in inches.

The diameter of a valve in inches, multiplied by the diameter in inches, equal the superficial content, or area of the valve, in circular inches, or what is termed *the square of the diameter;* and the square of the diameter multiplied by .7854 equal the superficial content in square inches, consequently the weight in lbs. on the safety valve, divided by the area in square or circular inches, equal the pressure in lbs. on each square or circular inch of the boiler.

When there is no lever attached to a valve, the weight divided by the area equal the direct pressure; but when a lever is applied, the principle of the lever must be taken into account, and may be estimated thus:—Ascertain the weight of the valve, and also the action of the lever upon the valve; the action is found sufficiently near by dividing the whole length of the lever by the distance between the fulcrum and the valve, and multiplying the quotient by half its weight.

In the following section of a valve with a lever



Let F denote the fulcrum,—P the whole pressure upon the valve,—D the distance of the weight from F,—*d* the distance between F and P,—*d d* the distance between F and D,—W the weight upon the lever,—and *p* the action of the lever upon the valve.

Then 1. $\dfrac{\overline{P - p} \times d}{d\,d} = W.$ 2. $\dfrac{\overline{P - p} \times d}{W} = D.$

$$3.\ \frac{W \times d\,d}{d} + p = P.$$

EXAMPLE.—Suppose 95 lbs. to be the whole weight or pressure required upon a valve, and the

Weight of the valve .... = 2 lbs.
Weight of the lever...... = 3 „
Distance between F and P = 3 inches.
Distance between P and D = 18 „

To find W, or the weight required upon the lever.

$\dfrac{18\ \textit{inches}}{3\ \textit{inches}} \times 1.5$ lbs. $+$ 2 lbs. $=$ 11 lbs. or the action of the lever and weight of the valve.

Hence, $\dfrac{\overline{95 - 11} \times 3}{18} = 14$ lbs. or W.

$\dfrac{\overline{95 - 11} \times 3}{14} = 18$ inches, or $d\,d$.

$\dfrac{14 \times 18}{3} + 11 = 95$ lbs. or P, the pressure upon the valve.

When greater accuracy is required, counterpoise the lever by weights at F, making P the centre of motion; hence, the weights at F, plus the weight of the lever, is the real action upon the valve. And the rules are the same throughout, whether a weight or spring balance be applied, observing to take the weight of the spring balance into account.

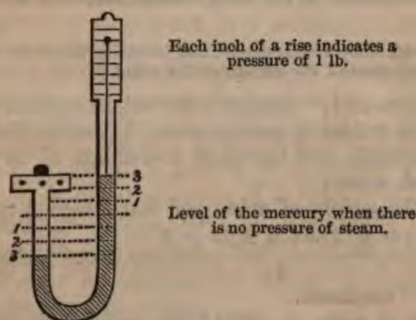
When a spring balance is applied to the lever of a safety valve, the distance between F and P = the diameter of the valve in inches, and the distance between F and the spring balance, or the end of the lever = as [illegible]times the diameter of the valve as there are square

a.

THE STEAM GAUGE

Is an indicator of constant reference in ascertaining the elastic force or pressure of the steam in a boiler, and which is very important to be known, for, according to the state of the fire, the steam may get so low as to allow a vacuum to be formed in the boiler, or it might be considerably too high, although escaping partly by the safety valve; hence, the steam gauge is a general test for regulating the fire; or if by any means the valve get fastened, and the steam still accumulating, the mercury will be driven out of the tube, and then become partially a safety valve.

The common construction of a steam gauge is an inverted syphon, or bent tube of wrought iron, containing a sufficiency of mercury to resist the required pressure of steam in the boiler, one end being fixed to the boiler, and the other open to the atmosphere; but the action of the column of mercury will appear more plain by means of the following section:—



The steam depresses the mercury in the short tube, consequently causes it to rise in the longer one; 2 inches of mercury is a counterpoise to 1 lb. pressure of steam, therefore a rise of 1 inch in the long tube indicates a force equal to 1 lb. per square inch in the boiler.

A FLOAT

Is as requisite for ascertaining the height of the water in a boiler as a gauge is for the height of the steam, but can only be properly applied in a land or fixed engine boiler, and may consist of either *stone, iron, copper*, or any other body that will not be destroyed by the heat of the water or force of the steam; hence, a float may be made so heavy as to sink in the water, consequently a counterpoise is required; or it may be made so buoyant that it will neither be steady in the boiler, sink to the depth required, nor will it fall by its own gravity when the water is getting low, therefore additional weight must be attached, and in either case the float immersed about $\frac{2}{3}$ds of its thickness or depth.

RULE 1.—*When too heavy*, subtract the weight of the water displaced from the weight of the float; the remainder is the counterpoise required.

RULE 2.—*When too buoyant*, subtract the weight of the float from the weight of the water displaced; and the remainder is the weight that must be added to the float.

NOTE.—The weight must either be inside the float, or otherwise attached, clear of the surface of the water.

EXAMPLE 1.—Required the weight necessary to counterpoise a float of paving stone, 14 inches diameter, $2\frac{1}{4}$ inches thick, and immersed two-thirds of its thickness in fresh water;

say, the weight of stone and rod attached $= 30\frac{1}{2}$ lbs.

then, $\frac{14^2 \times .7854 \times 2.25 \times 2}{3} = 230.9$ inches of water displaced.

1 inch of water $= .03617$ lbs. avoirdupois; hence,
$230.9 \times .03617 = 8.35$ lbs. of water displaced, and
$30.5 - 8.35 = 22.15$ lbs. required for a counterpoise.

EXAMPLE 2.—Suppose a float to consist of a concave copper ball, 12 inches diameter outside, and weigh with rod attached $7\frac{1}{4}$ lbs; required the weight that must be

added inside, so that the ball may remain immersed half its depth in fresh water.

$$\frac{12^3 \times .5236 \times .03617}{2} = 16.36 \text{ lbs. of water displaced,}$$

and $16.36 - 7.25 = 9.11$ lbs. that must be added to the float.

GAUGE COCKS AND GLASS TUBES

Are intended to show the height of water in a boiler where a float cannot properly be applied, as in *marine and locomotive engines;* they are also becoming common in *land* boilers, and are very necessary appendages, but require particularly strict attention under the following circumstances;—namely, *all new boilers, boilers immediately after being cleaned, and marine boilers in passing from fresh to salt water, or from salt to fresh, more especially water holding earthy and other matters in solution;* but in either case the water becomes frequently in a state of complete fermentation, the boiler appears to contain more than a sufficient quantity of water, when in reality there may not be *solid* water, as it is termed, at the first cock, which ought not to be less than from three to four inches above the top of the highest flue. Putting a few pounds of tallow in a marine boiler, previous to getting up steam, or firing light when fermentation, or *priming*, as it is frequently called, is likely to occur, are the usual modes of prevention; but the same applied to locomotive boilers, in many instances increase the fermentation in place of lessening it, and nothing but a boiler free from any earthy substance will thoroughly prevent it, which must be obtained by *blowing out*, and thoroughly changing the water.

It may not be amiss here to impress upon the mind the very great necessity of a constant sufficiency of water in the boiler, for a volume of steam suddenly formed is attended with considerably *greater danger* than an excess of steam regularly accumulated, as the safety valve will allow part to escape during its forma-

tion, and also give warning of its progression, but the valve cannot act so instantly and efficiently as is required if steam be suddenly generated, which, I have no doubt, is the case where some of the plates of a boiler are red hot when the engine is started, and if not the cause of an *explosion*, may be the means of materially injuring the boiler.

THE FEED PIPE AND FEED PUMP.

Boilers are supplied with water in two ways, namely, by the gravity of the water alone, and by means of a force pump applied to the engine.

When a boiler is supplied by the gravity of the water, the pipe attached to the top of the boiler, containing the column of water, is designated the feed pipe, the one from the pump being only for the purpose of conveying the water to the top of the feed pipe, the height of which requires to be at least $2\frac{1}{2}$ feet above the surface of the water in the boiler for every pound pressure on a square inch of the safety valve.

To ascertain the capacity of the feed pump,—

Let A represent the area of the piston in feet,
- V .... $\frac{3}{4}$ths of its velocity in feet per minute,
- Q .... the quantity of water in cubic inches contained in a cubic foot of steam, at the elastic force required,
- n .... the number of revolutions of the engine per minute,
- l .... the length of stroke of the pump in inches.
- d .... the diameter of the pump also in inches.

1728 cubic inches = 1 cubic foot,

And 277.274 = 1 imperial gallon;

Then

$$\left.\begin{array}{l}\dfrac{A\ V\ Q}{1728} = \text{cubic feet} \\[2ex] \dfrac{A\ V\ Q}{277.274} = \text{imperial gallons}\end{array}\right\}\text{of water required to be evaporated per minute.}$$

$$\text{Or } \sqrt{\frac{A\ V\ Q\ 5}{n\ l}} = d. \qquad \text{Also } \frac{A\ V\ Q\ 5}{n\ d^2} = l.$$

Thus, suppose a cylinder of 27 inches diameter, or about 4 feet area, length of stroke 5 feet, number per minute 22, or 220 feet velocity, steam 5 lbs. per square inch, and stroke of the pump 15 inches; required its diameter.

Number of cubic inches of water in a cubic foot of steam at 5 lbs. per square inch = 1.33—(*see Table, page 20.*) And $\frac{3}{4}$ths of 220 = 165.

Hence A = 4, V = 165, Q = 1.33, n = 22, and l = 15.

$$\sqrt{\frac{4 \times 165 \times 1.33 \times 5}{22 \times 15}} = 3.7 \text{ inches diameter.}$$

$$\text{Or, } \frac{4 \times 165 \times 1.33 \times 5}{22 \times 3.7^2} = 15 \text{ inches, length of stroke.}$$

NOTE.—The suction and delivering pipes to any pump ought not to be less than two-thirds of the pump's diameter; and in the delivering pipe to the boiler, in high-pressure engines, particularly locomotives, a small *cock* should be inserted, so as to allow the steam and air which accumulates in the pipes to escape, otherwise the boiler is frequently prevented from being regularly supplied.

THE BOILER.

The *boiler* is a vessel of either *wrought iron, cast iron,* or *copper,* and contains water to which heat is applied, and steam generated. Boilers are not confined to any one particular form, having for their general principle *strength, compactness, and durability,* and containing the greatest superficial heating surface under the least cubical content; hence, their forms are so exceedingly various, that any attempt here to introduce either plans or specifications would be quite inconsistent with the design of this work, and of comparatively little value in point of daily reference; but, there are several rules and proportions, deduced from experiment and practice, that are of particular advantage, and ought to be attended to.

1.—*Boilers to which coal is applied in the usual form.*

In such boilers it is ascertained that about 500 square feet of effective heating surface, having about 60 square or superficial feet of fire properly applied, will evaporate one cubic foot of water per minute; hence, when the quantity of steam required is known, the quantity of heating surface and extent of fire-grate is easily obtained, and this depends considerably upon the *eccentric and slide valve.*

From the nature of an eccentric, although a valve has neither lap nor lead, the steam admitted into the cylinder is only about $\frac{3}{4}$ths the capacity of the cylinder, consequently $\frac{3}{4}$ths the piston's velocity, and when the steam is sooner cut off, as it generally is, an additional saving is obtained, but on account of the waste of steam in the apertures, imperfections, &c. it is not prudent to calculate a boiler for less. Hence, to determine the effective heating surface in a boiler,

Let A denote the area of the cylinder in feet.
P .... $\frac{3}{4}$ths of the piston's velocity in feet per min.
500 .... the effective heating surface to evaporate 1 cubic foot of water per minute.
V .... the volume of steam from 1 of water.
And S .... the effective heating surface required in square feet.

$$\text{Then, } \frac{A\ P\ 500}{V} = S.$$

Ex.—Suppose A = 3 feet.
P = 165, or say the velocity of the piston = 220 feet per minute.
4 lbs. per sqr. inch the pressure required.
To find S, or the heating surface in the boiler.

The volume of steam at 4 lbs. per square inch, produced from one of water, = 1366—*(see Table, page 20.)*

$$\text{Then } \frac{3 \times 165 \times 500}{1366} \doteq 181.2 \text{ square feet.}$$

And 181.2 × .12 = 21.75 square feet of fire-grate.

The proportions for waggon-shaped boilers are as follow :—

Half the effective heating surface = the bottom surface.

Twice the square root of the bottom surface in feet = the length.

Half the square root in feet = the width. And

One-third the length = the height.

NOTE.—All horizontal surfaces over fire, flame, or heated air, are effective; but vertical or side surfaces require about 1.75 feet to be equally effective to one of horizontal surface.

EXAMPLE.—Let the effective heating surface of a boiler = 120 feet; then 60 = the bottom surface, and

$\sqrt{60} \times 2 = 15.48$ feet, the length.
$\sqrt{60} \div 2 = 3.87$ „ width.
$15.48 \div 3 = 5.16$ „ height. About twice the length and width of the boiler = the length of the flue, And $60 \times 1.75 = 105$ feet of side surface, then $15.48 \times 2 + 3.87 = 34.8$; hence $\frac{105}{34.8} = 3$ feet, the depth of the side surface.

Again,—In cylindrical boilers $\frac{1}{3}$rd must be added to the effective heating surface, so as to make the curve surface = to horizontal surface; hence, suppose 60 feet = the effective surface,

$\sqrt{60 + 20} = 8.94$ feet, or half the circumference of the boiler,

And $8.94 \times 2 = 17.88$ feet the length.

Boilers are frequently made with internal flues, with a view to increase the quantity of heating surface, and reduce the cubical capacity of the boiler: when such is the case, let the effective heating surface gained be taken from the length of the boiler, and not from the width, as the heat will be sufficiently given out by the extra length of flue inserted.

The depth, or body of water contained in a boiler, ought to be about $\frac{2}{3}$rds of the whole height of the boiler, for when there is a considerable body of water in a boiler the steam is less liable to fluctuation.

2.—*Boilers for locomotives where coke is used, and a blast pipe applied.*

In boilers of this description the evaporating power depends, in a great measure, upon certain proportions existing between the *tubes, the chimney, and the orifice of the blast pipe.*

The blast pipe in a locomotive is a copper or other metal tube, for the purpose of conducting the steam from the cylinders to the bottom of the chimney, so that it may there be emitted at a certain velocity, to expel the air in the chimney, and cause a current of heated air to pass from the fire through the tubes at each half stroke of the engines ; consequently, the more the heated air is diffused in the boiler by a number of tubes or pipes, the less is the current required to be, and the larger the orifice of the blast pipe, for the following reason :—*A tube twice the diameter contains only twice the circumference or heating surface, but four times the area ;* hence, in large tubes the velocity must be considerably increased, so as to compensate for the loss of heated air passing through the body of the tube. But,

Although a greater quantity of tubes would diffuse a greater quantity of heat through the water, other circumstances interfere, as the quality of the coke, &c., therefore practice has dictated a certain size as the most beneficial to be used, and I believe it is generally found that brass tubes, 2 inches diameter outside, and about No. 14 wire gauge, are the most advantageous.

Again, the diameter of the *chimney* materially affects the blast pipe, for the wider the chimney the greater is the column of air to displace,—hence, the smaller the orifice of the blast pipe ; but, indeed, they are so linked together that nothing but several trials with the engine can decide the exact proportions, so that the one part may accommodate the other.

However, in practice we find that a boiler, containing about 90 two-inch tubes, having a 12-inch chimney, and a $2\frac{5}{8}$-inch *blast pipe*, will generate a sufficiency of steam,

from 50 to 60 lbs. per square inch above the pressure of the atmosphere, to supply two cylinders 12 inches diameter each.

NOTE.—The chimney is generally the same diameter as the cylinder, and about 6 feet long.

It is also ascertained from practice, that about three square feet of heating surface in the fire-box, or nine square feet in the tubes, will evaporate one cubic foot of water per hour in a boiler as already described, and kept under like circumstances, from which we deduce the following rule :—

Let V = the velocity of the engine in feet per hour,
l = „ length of the stroke in feet,
p = „ area of the piston in feet,
3 = „ effective evaporating surface in the boiler to each cubic foot of water,
d = „ diameter of the wheels in feet,
r = „ ratio, or volume of steam from one of water.
And S = „ effective generating surface of the boiler in square feet;

$$\text{Then } \frac{V\ l\ p\ 3}{r\ d} = S.$$

EXAMPLE.—Suppose a locomotive with two cylinders of 11 inches, or .917 feet diameter each, stroke 1.33 feet, wheels 5 feet diameter, velocity 20 miles per hour, force of steam 50 lbs. above the pressure of the atmosphere; required the effective heating surface in the boiler.

$.917^2 \times .7854 = .66$ feet, area of the piston.
$5280 \times 20 = 105600$ feet, velocity of the engine per hour.
$435 =$ the volume of steam to one of water—(*see Table, page* 20.)

$$\text{Hence } \frac{105600 \times 1.33 \times .66 \times 3}{435 \times 5} = 128 \text{ square feet.}$$

And $\frac{1}{3}$ of 128 = 43 square feet in the fire-box.

The tube surface, or communicative heat, requires to

be multiplied by 3, as before stated, to equal the surface in the fire-box, or radiating caloric; therefore $128 - 43 = 85 \times 3 = 255$ square feet of surface in the tubes.

And, Suppose the tubes 7 feet in length, $\frac{255}{7} = 36.43$ feet for the whole circumference of the tubes.

Again, Suppose each tube $1\frac{3}{4}$ inches inside, or nearly 5.5 circumference,

$$\frac{36.43 \times 12}{5.5} = 80 \text{ tubes contained in the boiler.}$$

A Table of the weight of a superficial foot of various metals in lbs. avoirdupois.

NAMES.	THICKNESS IN PARTS OF AN INCH.											
	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1 in
Iron in lbs ...	2.5	5	7.5	10	12.5	15	17.5	20	25	30	35	40
Copper in lbs	2.9	5.8	8.7	11.6	14.5	17.4	20.3	23.2	28.9	34.7	40.4	46.2
Brass in lbs...	2.7	5.5	8.2	10.9	13.6	16.3	19	21.8	27.1	32.5	37.9	43.3
Lead in lbs...	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	37	44.4	57.8	59.2

NAMES.	THICKNESS BY THE BIRMINGHAM WIRE GAUGE.									
	1	2	3	4	5	6	7	8	9	10
Iron in lbs ...	12.5	12	11	10	8.74	8.12	7.5	6.86	6.24	5.62
Copper in lbs	14.5	13.9	12.75	11.6	10.1	9.4	8.7	7.9	7.2	6.5
Brass in lbs...	13.75	13.2	12.1	11	9.61	8.93	8.25	7.54	6.86	6.18

NAMES.	THICKNESS BY THE WIRE GAUGE.									
	11	12	13	14	15	16	17	18	19	20
Iron in lbs ...	5	4.38	3.75	3.12	2.82	2.5	2.18	1.86	1.7	1.54
Copper in lbs	5.8	5.08	4.34	3.6	3.27	2.9	2.52	2.15	1.97	1.78
Brass in lbs...	5.5	4.81	4.12	3.43	3.1	2.75	2.4	2.04	1.87	1.69

NAMES.	THICKNESS BY THE WIRE GAUGE.									
	21	22	23	24	25	26	27	28	29	30
Iron in lbs ...	1.4	1.25	1.12	1	.9	.8	.72	.64	.56	.5
Copper in lbs	1.62	1.45	1.3	1.16	1.04	.927	.835	.74	.649	.58
Brass in lbs...	1.54	1.37	1.23	1.1	.99	.88	.79	.7	.616	.55

PROPERTIES OF VARIOUS METALS.

Welding heat of iron 12780° Ft....1 foot in length contracts in cooling .137 of an inch.
Power of conducting heat to another body 37.41.
Copper melts at 4587° Ft. ....contracts in cooling .193.
Conducting heat ....89.82.
Brass melts at 3807° Ft......................... contracts in cooling .210.
Conducting heat about the same as copper.
Lead melts at 594° Ft. .... contracts in cooling .319.
Conducting heat.........................17.96.
Tin melts at 442° Ft. .... contracts in cooling .278.
Conducting heat.........................30.38.
Water expands in heating from 32° to 212°, about 0.0434. of its bulk.

THE STEAM-ENGINE.

Steam-engine is the general term applied to any machine having for its moving power the elastic force of steam; hence, the usual names, *low pressure*, *high pressure*, *rotatory*, and *locomotive steam-engines;* and although differing in plan and application, still remain the same in principle—namely, steam is the moving power. And, the moving power or elastic force of the steam, multiplied into the velocity of the engine, constitutes the amount of useful effect in giving motion to machinery, propelling vessels, locomotives, &c.

It is well known that the moving power in the greater portion of engines consists of an alternate rectilinear or reciprocating motion, communicated to a crank, whereby a continued circular motion is obtained and rendered uniform by a fly-wheel, or otherwise—as, when employed in propelling vessels, the motion is transferred to the vessel itself by the resistance of the paddles in the water, the velocity of which cause a similar uniformity in the engine; and the same takes place in a locomotive, by the adhesion of the wheels to the rails; hence,

the alternate motion of the piston governs the velocity of the engine, and is not at all confined, for the greater the force the greater the velocity, and the greater the velocity the greater the power, providing there be a constant sufficiency of steam to continue the motion and overcome the resistance to which the engine is applied. But,

There is a maximum velocity for an engine, or that velocity whereby the greatest effect is produced from the pressure of steam applied; and, to ascertain this point, the uniform force of the steam throughout the stroke must first be obtained by the following rule :—

Divide the length of the stroke in inches by the distance the piston has moved before the steam is cut off, and divide the whole pressure on a square inch of the piston in lbs. by the quotient. Add 1 to the hyperbolic logarithm of the number of times the steam is expanded, and multiply the logarithm by the number of lbs. to which the steam is expanded, and the product is the uniform force of the steam.

Table of Hyperbolic Logarithms.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1¼	.2231435	5¾	1.7491998	15	2.7080502	33	3.4965075
1½	.4054651	6	1.7917594	16	2.7725887	34	3.5263605
1¾	.5596157	6¼	1.8325814	17	2.8332133	35	3.5553480
2	.6931472	6½	1.8718021	18	2.8903717	36	3.5835189
2¼	.8109302	6¾	1.9095425	19	2.9444389	37	3.6109179
2½	.9162907	7	1.9459101	20	2.9957322	38	3.6375861
2¾	1.0116008	7¼	1.9810014	21	3.0445224	39	3.6635616
3	1.0986123	7½	2.0149030	22	3.0910424	40	3.6888794
3¼	1.1186549	7¾	2.0476928	23	3.2354942	41	3.7135720
3½	1.2527629	8	2.0794415	24	3.1780538	42	3.7376696
3¾	1.3217558	8½	2.1400661	25	3.2188758	43	3.7612001
4	1.3862943	9	2.1972245	26	3.2580965	44	3.7841896
4¼	1.4469189	9½	2.2512917	27	3.2958368	45	3.8066624
4½	1.5040774	10	2.3025851	28	3.3322045	46	3.8286414
4¾	1.5581446	11	2.3978952	29	3.3672958	47	3.8501476
5	1.6094379	12	2.4849066	30	3.4011973	48	3.8712010
5¼	1.6582280	13	2.5649493	31	3.4339872	49	3.8918203
5½	1.7047481	14	2.6390573	32	3.4657359	50	3.9120230

To find the maximum velocity of an engine,—

Let S represent the uniform force of the steam in lbs. on each square foot of the piston, atmospheric pressure included,

Q .... the quantity of steam in cubic feet that enters the cylinder per minute,

c .... area of the cylinder in square feet,

1152 lbs...... pressure on each square foot of the piston, as required to overcome the friction of the engine, change the motion from a reciprocating to a circular, &c,

r .... resistance on each square foot of the piston in a condensing engine, on account of imperfect vacuum. In non-condensing engines the resistance is the pressure of the atmosphere, or 2117 lbs. per square foot,

n .... number of horses' power, or so many times 150 lbs.,

l .... length of the stroke in feet,

and V........ velocity of the engine in feet per min.

then $$\frac{S\,Q\,c}{1152 + r\,c + n\,l} = V.$$

EXAMPLE.—Suppose an engine and boiler under the following circumstances:—

Effective generating surface in the boiler	181 sqr. ft.
Force of steam above the pressure of the atmosphere on a square inch....	4 lbs.
Atmospheric pressure included	19 „
Diameter of cylinder	2 feet.
Length of stroke..................	5 „
Steam cut off when the piston has moved	40 inches.
Resistance to be overcome	3000 lbs., or,

in effect, 20 horses' power.

Average vacuum, 26 inches of mercury; required the velocity in feet per minute.

500 square feet of heating surface will evaporate 1 cubic foot of water per minute, and 1 cubic foot of water evaporated equal 1366 cubic feet of steam at 4 lbs. per square inch above the pressure of the atmosphere,—(*see Table, page* 20,)—hence,

$\frac{1366 \times 181}{500} = 494$ cubic feet of steam per minute, of which, suppose about 486 feet enter the cylinder.

Again, $60 \div 40 = 1.5$, and $19 \div 1.5 = 12.66$. Also, $\overline{1 + .4054651} \times 12.66 = 18$ lbs. of uniform pressure per square inch; consequently,

$S = 144 \times 18$, or 2592 lbs. per square foot,
$Q = 486$, or the quantity of steam in cubic feet per minute,
$c = 2^2 \times .7854$, or about 3 square feet, area of cylinder,
$r = 2$ lbs. per square inch, or 288 lbs. per square foot,
$n = 150 \times 20$, or 3000,
And $l = 5$ feet.

$$\frac{2592 \times 486 \times 3}{\overline{1152 + 288} \times 3 + \overline{3000 \times 5}} = 195 \text{ feet velocity per minute.}$$

But there are various nominal velocities to which engines are frequently regulated, varying with the opinions of different engineers, the most popular of which are the following:—

1. That all engines, without exception, ought to be regulated at a constant velocity of 220 feet per minute, having neither respect to the force of the steam nor length of the stroke. And,

2. That 100 times the square root of the length of the stroke in feet equal the velocity in feet per minute.

The following Table of Velocities is the result of practice and observation :—

Land Engines.				*High Pressure Engines.*				*Marine Engines.*			
Length of stroke in ft. & in.		*Number per minute.*	*Velocity in feet per minute.*	*Length of stroke in ft. & in.*		*Number per minute.*	*Velocity in feet per minute.*	*Length of stroke in ft. & in.*		*Number per minute.*	*Velocity in feet per minute*
1	6	50	150	1	0	80	160	2	0	42	168
2	0	43	172	1	6	62	186	2	3	39½	177¾
2	6	38	190	2	0	50	200	2	6	36	180
3	0	34	204	2	6	42½	212½	2	9	33	181
3	6	30	210	2	9	39½	217¼	3	0	31	186
4	0	27	216	3	0	37	222	3	6	27	189
4	6	24¼	218¼	3	6	33	231	4	0	24	192
5	0	22	220	4	0	29½	236	4	6	21½	193½
5	6	20¼	224¾	4	6	27	243	5	0	20	200
6	0	19	228	5	0	24¾	247½	5	6	19	209
7	0	17½	245	5	6	23	253	6	0	18	216
8	0	16	256	6	0	22	264	7	0	15¾	220½

These are to be considered as the velocities of engines having the application of their power in the usual form. Sometimes the motion is communicated by a lever or half beam, and having the power transmitted from somewhere between the fulcrum and the piston, or end of the lever, in which case the velocity of the engine must be increased in the following proportion :—

Rule.—Multiply the velocities in the table by the length of the lever in feet between fulcrum and piston, and divide the product by the distance between the fulcrum and connecting rod, the quotient is the velocity in feet per minute.

Example.—Suppose a marine engine of this description with a 3 feet 6 in. stroke, length of lever 11 feet, and the connecting rod attached 2½ feet from the piston; required the piston's velocity.

By the table, a 3 feet 6 stroke = 189 feet per minute,

$$\text{and } \frac{189 \times 11}{8.5} = 244.5 \text{ feet.}$$

In the velocities of marine engines, the vessels are supposed in their average sailing trim, in moderate weather, and the dimensions of the paddle boards determined according to the following approximate :—

RULE.—Multiply the area of the cylinder in inches by *nine times* the force of the steam in lbs. on a square inch of the boiler above the pressure of the atmosphere, divide the product by the diameter of the wheels in feet multiplied by the velocity of the piston in feet per minute, and the quotient is the area of each paddle board in square feet for vessels with two engines, and half the quotient for vessels with one engine only.

EXAMPLE.—Suppose a vessel containing two engines, with cylinders of 50 inches diameter each, stroke $4\frac{1}{2}$ feet, wheels 20 feet diameter, and steam at 4 lbs. per square inch above the pressure of the atmosphere; required the area of each paddle board in square feet.

$50^2 \times .7854 = 1963.5$ inches, area of cylinder; $9 \times 4 = 36$; and by the table a $4\frac{1}{2}$ feet stroke $= 193\frac{1}{2}$ feet velocity.

Hence, $\frac{1963.5 \times 36}{193.5 \times 20} = 18.2$ feet; and suppose each 8 feet in length, $18.2 \div 8 = 2.28$, or 2 feet 3 inches broad nearly.

NOTE.—In the preceding table of velocities the pressure of the steam for land engines is taken at an average of 3 lbs., high pressure engines 30 lbs., and marine engines 4 lbs. per square inch above the pressure of the atmosphere.

Velocity of locomotive engines.

In order to ascertain what load a locomotive engine is able to draw at a given velocity, or what velocity it will acquire with a given load, the following require to be taken into account, namely,—

The force of the steam; the pressure of the atmosphere; the dimensions of the cylinders; the diameter of the wheels; the weight of the load; the force of traction per ton; and the friction of the engine. It is already decided by experiment and practice, that about

9 lbs. per ton is the amount of the force of traction upon a level, when the line of rails and waggon axles are kept in proper condition, the bearings of the axles being from 4 to $4\frac{1}{2}$ inches in length by $2\frac{1}{2}$ in diameter, and wheels about 3 feet diameter; and also the amount of resistance and friction of the engine per ton equal about 15 lbs. (The quantity of water that a boiler will evaporate in a given time is given under the section on boilers, see page 31.) Hence, in both cases,

Let P denote the total pressure of steam in the boiler per square foot (atmospheric pressure included,)
- r .... the ratio of the volume of steam, water being 1, or the volume of steam to the volume of water that produces it,
- S .... the quantity of water evaporated per hour in cubic feet,
- D .... the diameter of the wheels in feet,
- 9 lbs. the resistance of the load per ton,
- W.... the gross weight of the load in tons, tender, water, &c. included,
- 15 lbs. the resistance and friction of the engine per ton.
- 2117 lbs. the atmospheric pressure per square foot,
- d .... the diameter of the cylinders in feet, or parts of a foot.
- l .... the length of the stroke also in feet,

And V .... the velocity in feet per hour. Then,

1. To ascertain the load that a given engine will draw with a fixed pressure and a determined velocity.

$$\frac{\overline{P\,r\,S\,D} - \overline{2117\,d^2\,l\,V}}{V\,9\,D} - \frac{15 \text{ per ton}}{9} = W$$

2. To ascertain the velocity to which an engine will acquire with a fixed pressure and a determined load.

$$\frac{P\,r\,S\,D}{(9W + 15)D + 2117\,d^2\,l} = V$$

EXAMPLE.—Suppose an engine of the following dimensions, namely,

Diameter of cylinders 11 inches, or .917 feet.
Stroke of the piston 16 „ or 1.33 „
Diameter of wheels 5
Effective pressure 50 lbs. per square inch, or 65 lbs. atmospheric pressure included,
38.74 cubic ft. of water evaporated per hour,
Weight of the engine 8 tons,
Load, gross weight, tender included, 100 tons ;

Required the velocity in miles per hour.

$144 \times 65 = 9360$ lbs. pressure of steam per square foot, or P,
$435 =$ the volume of steam to 1 of water,—(*see Table, page* 20.)
$100 \times 9 = 900$ lbs. resistance of the load,
$15 \times 8 = 120$ lbs. resistance and friction of the engine,

And 5280 feet = 1 mile. Then,

$$\frac{9360 \times 435 \times 38.74 \times 5}{\overline{900 + 120} \times 5 + \overline{2117 \times .9172 \times 1.33}} = 105612 \text{ ft.}$$

$$\text{and } \frac{105612}{5280} = 20 \text{ miles per hour.}$$

Again, Suppose the engine as before, but with a fixed velocity of 20 miles per hour; required the load it will take in gross tons, tender included.

$$\frac{9360 \times 435 \times 38.74 \times 5 = 2117 \times .917^2 \times 1.33 \times 105600}{105600 \times 9 \times 5} =$$

$$113.13 - \frac{120}{9} = 100 \text{ tons.}$$

A Table containing the Velocities of Engines, with their given loads.

DESCRIPTION OF THE ENGINE.	*Load in gross tons, tender included.*	*Velocity on a level, in miles per hour, with an effective pressure of steam in the boiler at 50 lbs. 55 lbs. and 60lbs. per square inch.*		
	Tons.	*50 lbs.* *Miles.*	*55 lbs.* *Miles.*	*60 lbs.* *Miles.*
Engine with cylinders 11 in. diam. Stroke of the piston 16 in. Diameter of the wheels 5 feet. Weight of the engine 9½ tons. Effective heating surface 140 square feet. Water evaporated per hour 42 cubic feet.	25	40.07	40.38	40.60
	50	31.34	31.58	31.76
	75	25.74	25.93	26.06
	100	21.83	22.00	22.12
	125	18.96	19.10	19.21
	150	16.75	16.88	16.97
	175	......	15.12	15.21
	200	......	......	13.60
Engine with cylinders 12 in. diam. Stroke of the piston 16 in. Diameter of wheels 5 feet. Weight of the engine 11 tons. Effective heating surface 140 square feet. Water evaporated per hour 42 cubic feet.	25	34.45	34.71	34.91
	50	27.80	28.01	28.16
	75	23.29	23.47	23.60
	100	20.05	20.21	20.32
	125	17.60	17.73	17.83
	150	15.68	15.80	15.89
	175	14.14	14.25	14.33
	200	......	12.98	13.05
	250	......	......	10.75
Engine with cylinders 13 in. diam. Stroke of the piston 16 in. Diameter of wheels 5 feet. Weight of the engine 12 tons. Effective heating surface 160 square feet. Water evaporated per hour 48 cubic feet.	50	29.03	29.25	29.42
	75	24.68	24.86	25.00
	100	21.46	21.62	21.74
	125	18.98	19.13	19.23
	150	17.02	17.15	17.24
	175	15.42	15.54	15.63
	200	14.10	14.21	14.29
	225	12.99	13.09	13.16
	250	......	11.80	11.72
Engine with cylinders 12 in. diam. Stroke of the piston 18 in. Diameter of wheels 5 feet. Weight of the engine 12 tons. Effective heating surface 160 square feet. Water evaporated per hour 48 cubic feet.	50	26.16	26.36	26.51
	75	22.57	22.74	22.87
	100	19.85	20.00	20.11
	125	17.71	17.85	17.95
	150	15.99	16.11	16.20
	175	14.57	14.68	14.77
	200	13.39	13.49	13.56
	270	......	......	11.05

This table supposes the resistance of the air to be nothing more than what is created by the train or load; a fresh breeze makes a very considerable difference; for

in the first case the resistance is only about 17 or 18 lbs. on a waggon of moderate height; but, if the velocity of the wind be about 20 feet per second, the resistance is equal to .915 lbs. per square foot,—or otherwise, a surface of one square foot, cutting the air with a velocity of 20 feet per second, meets with a resistance of .915 lbs.; hence, a surface of 30 square feet must meet with a resistance of $.915 \times 30 = 27.45$, or nearly $27\frac{1}{2}$ lbs.

Any rise or inclined plane upon a railway materially diminishes the velocity, or lessens the quantity of load an engine can take upon a level, on account of the resistance upon the plane approaching to the total weight of the load, for, according to the laws of inclined planes, the resistance or weight increases as the perpendicular height of the plane is to its length; hence, divide the weight of the load in lbs., including engine and tender, by any portion or length of the plane multiplied by 8, or the traction of the load per ton minus the friction of the engine, and the quotient, plus the weight of the load in tons, multiplied by 8, equal the total resistance of the load in lbs. upon the plane.

Example.—Suppose a train or load of 100 tons, engine, tender, &c. 12 tons, which, upon a level, offers a resistance of $112 \times 8 = 896$ lbs.; required the increase of resistance upon an incline of 1 in 135.

$$2240 \text{ lbs.} = 1 \text{ ton}; \text{ and } \frac{2240 \times \overline{100 + 12}}{135 \times 8} = 232 + 100 = 332 \text{ tons}, \times 8 = 2656 \text{ lbs.}$$

And the velocity acquired by a carriage or train descending a plain, although inversely, increases in an equal ratio; *hence, the necessity for individuals intrusted with the care or management of locomotive engines being particularly acquainted with the various effects of a train or load upon an incline, as well for their own as public safety, so that, by a competent knowledge, and proper attention, the engine may be regulated to a constant or uniform velocity, whereby general safety in a great measure is secured.*

A Table containing the Resistance of Trains upon inclined planes.

Weight of the Engines.	Weight of the train in gross tons, tender included.	Load in gross tons, which on a level would offer the same resistance, the inclination of the plane being						
		$\frac{1}{500}$	$\frac{1}{400}$	$\frac{1}{300}$	$\frac{1}{250}$	$\frac{1}{200}$	$\frac{1}{150}$	$\frac{1}{100}$
Engine weighing 8 tons.	25	44	48	56	62	71	87	117
	50	83	91	105	115	131	158	212
	75	122	133	153	148	191	230	307
	100	161	176	201	221	251	302	402
	125	200	218	249	274	311	373	497
	150	239	261	298	327	371	445	592
Engine weighing 10 tons.	25	45	50	58	64	74	91	123
	50	84	93	107	117	134	162	218
	75	123	135	155	170	194	234	313
	100	162	178	203	223	254	306	408
	125	201	220	251	276	314	377	503
	150	240	263	300	329	374	449	598
	175	279	305	348	382	434	521	693
	200	318	348	396	435	494	592	788
Engine weighing 12 tons.	25	46	51	60	67	77	95	129
	50	85	94	109	120	137	166	224
	75	124	136	157	173	197	238	319
	100	163	179	205	226	257	310	414
	125	202	221	253	278	317	381	509
	150	241	264	302	332	377	453	604
	175	280	306	350	385	437	525	699
	200	319	349	398	438	497	596	794
	225	358	392	446	491	557	668	889
	250	397	434	494	544	617	740	984

THE CYLINDER

Is the source from which the motion of an engine is derived, and also the bounds or extent by which the power is determined; hence, some of its various properties require observation and recollection.

1. In diameter it is the most capacious of all plain figures, or contains the greatest area within the same perimeter or outline.

2. The ratio of the diameter is to its circumference as 1 to 3.1416; twice the diameter contains twice the circumference; hence, the piston of a large engine has less rubbing surface, or less friction, according to its power, than a small one.

3. The areas of circles are to each other as the squares of their diameters, or as .7854 to 1: a circle twice the diameter contains four times the area.

Example 1.—Required the circumference and area of a circle, or end of a cylinder, 20 inches diameter.

$20 \times 3.1416 = 62.832$ inches circumference.
$20^2 \times .7854 = 314.16$,, area.

Example 2.—What is the circumference and area of a circle or piston 40 inches diameter?

$40 \times 3.1416 = 125.664$ inches, or twice 62.832.
$40^2 \times .7854 = 1256.64$,, or four times 314.16.

The whole capacity of a cylinder is equal to the area of the end multiplied by the perpendicular height.

Connected with the preceding remarks on the cylinder, and of equal importance, are the following on steam, in ascertaining the power or effect of an engine:—

In the steam-engine highly rarified steam is of considerably more advantage than steam of a more moderate elastic force. And,

1. On account of the very great increase of force obtained, from a comparatively small increase of heat, as exhibited in the following table:—

Elastic force in atmospheres.	Elastic force in lbs. per sqr. inch.	Degrees of heat.	Difference of temperature	Volume in cubic feet, water being 1.	Velocity into a vacuum in feet per sec.
1	14.7	212° F		1711	1566
2	29.4	250.52	38.52° F	905	1610
3	44.1	275.18	24.66	623	1638
4	58.8	293.72	18.54	479	1658
5	73.5	308.84	15.12	394	1674
6	88.2	320.36	11.52	331	1688
7	102.9	331.70	11.34	288	1700
8	117.6	341.96	10.26	255	1710
9	132.3	350.78	8.82	229	1720
10	147.0	358.88	8.10	209	1729
12	176.4	374.00	15.12	190	1742
15	180.5	392.86	18.86	135	1765
20	294.0	418.45	25.59	111	1786
30	441.0	457.16	38.71	77	1823
50	735.0	510.60	53.44	42	1873

Hence it follows, as a matter of consequence, that, as such small accessions of heat produce so rapid an increase of expansive force, small abstractions of heat from highly elastic steam will also reduce its elasticity in an equal degree, so that high pressed steam is more readily diminished in bulk by the application of cold than weaker steam; that is, it can be more readily reduced in its pressure to any certain proportion of the pressure it had before.

2. By admitting but a small portion of steam to enter the cylinder, and by its expansive force continue the motion of the piston to the end of the stroke.

When an engine is about to be set in motion, the steam has to overcome the friction and inertia of the whole mass; but, when once set in motion, the impetus it has acquired continues it in that state for a time, independently of the action of the steam, friction being only now to be overcome; hence, if the steam continue to act as forcibly as at first, it will communicate addi-

tional motion to the piston, and will, therefore, perform its stroke with accelerated velocity; but if the supply of steam is cut off at any part of the stroke, the remainder requires to be effected partly by the impetus the piston has already acquired, and partly by the expansion of the steam, its force from this source becoming less just in proportion as the space it occupies increases, thus the motion is in a great measure equalized,—the action of the steam in full strength sets it in motion, and the small and decreasing force requisite to continue the motion at a uniform rate is furnished by the expansion of that steam; the advantage gained by thus economizing the steam increases in proportion as the steam is sooner cut off to the extent indicated in the following table:—

If the steam is stopped	The effect of the quantity of steam
at $\frac{1}{2}$ the stroke,	admitted is multiplied by 1.7
$\frac{1}{3}$	2.1
$\frac{1}{4}$	2.4
$\frac{1}{5}$	2.6
$\frac{1}{6}$	2.8
$\frac{1}{7}$	3.0
$\frac{1}{8}$	3.2

Thus,—Suppose only one-fourth of the steam necessary to fill the cylinder is employed, the effect produced is more than one-half of the effect which would have been produced in filling the whole cylinder full of steam. Hence, the ratio between the force of the steam giving the first impulse to the piston, and the force of the steam at the termination of the stroke, constitutes the uniform elastic force throughout the whole stroke. (For a rule to obtain the uniform force of the steam *see page* 34.)

In calculating the power of an engine, the area of the piston multiplied by the uniform force of the steam, minus the resistance and friction of the engine, equal the effective moving power; and the effective moving power multiplied by its velocity per minute equal the momentum, or useful effect of the engine: and also, the

momentum divided by 150 lbs. $\times$ 220 feet, or 33,000 lbs., equal the standard of reference, or number of horses' power.

In high-pressure, or non-condensing engines, the resistance and friction remain nearly a constant number, namely, 18 lbs. per square inch, including the resistance of the atmosphere. Condensing engines vary with the state of the engine or extent of the vacuum, the mercury in the barometer attached to the condenser frequently ranging between 24 and $28\frac{1}{2}$, or at an average of $26\frac{1}{4}$ inches; hence, the pressure of the atmosphere being on an average 14.7 lbs. per square inch, and equal to a column of mercury 30 inches in height, $30 : 14.7 :: 26.25 : 12.86$ lbs., and $15 - 12.86 =$ about 2 lbs. resistance to each square inch of the piston's area, besides 8 lbs. required to overcome the friction and inertia of the engine, making the total resistance and friction about 10 lbs. per square inch, or 7.85 lbs. per circular inch of the piston. Hence,

THE GENERAL RULE.

Let D equal the diameter of the cylinder in inches,
F .... uniform force of the steam in lbs. per circular inch of the piston, atmospheric pressure included,
r .... resistance and friction of the engine in lbs. per circular inch,
V .... velocity of the piston in feet per minute,
33000 lbs. .. standard of one horse power,
And P .... the useful effect of the engine expressed in horses' power.

Then 1.
$$\frac{D^2 \times \overline{F - r} \times V}{33000} = P.$$

And 2.
$$\frac{33000 \times P.}{V \times \overline{F - r}} = D.$$

EXAMPLE 1.—Suppose it be required to ascertain the

power of a condensing engine, having the following particulars, viz.,

Cylinder 20 inches diameter,
Stroke 4 feet, or 216 feet velocity per minute,
Weight on each circular inch of the safety valve $2\frac{1}{2}$ lbs. or $11.78 + 2.5 = 14.28$ lbs. atmospheric pressure included.
Steam cut off from the cylinder when the piston has moved $\frac{2}{3}$rds of the stroke, or 32 inches.
Resistance and friction 10 lbs. per square inch, or 7.85 lbs. per circular inch; required the useful effect of the engine in horses' power.

$\frac{48}{32} = 1.5$, and $\frac{14.28}{1.5} = 9.52$. The hyperbolic logarithm of $1.5 + 1 = 1.40546 \times 9.52 = 13.37$ lbs. per circular inch of uniform elastic force, and $13.37 - 7.85 = 5.52$ lbs. effective force; hence,

$$\frac{20^2 \times 5.52 \times 216}{33000} = \frac{476928}{33000} = 14.4 \text{ horses' power.}$$

EXAMPLE 2.—Required the diameter of the cylinder for a condensing engine of 14.4 horses' power, and also the weight on each circular inch of the safety valve, in order to produce steam of 13.37 lbs. uniform elastic force, the steam to be cut off from the cylinder when the piston has moved 32 inches of its stroke—velocity of the piston 216 feet per minute—resistance and friction 7.85 lbs. per circular inch; $13.37 - 7.85 = 5.52$ lbs. effective power of the steam per circular inch; hence,

$$\sqrt{\frac{33000 \times 14.4}{216 \times 5.52}} = \frac{475200}{1192} = \sqrt{400} = 20 \text{ in. dia.}$$

Again, 4 feet = 48 inches, and $\frac{48}{32} = 1.5$; the hyperbolic logarithm of 1.5 plus 1 = 1.4054; hence, $\frac{13.37 \times 1.5}{1.4054} = 14.28$ lbs. total force of steam in the

boiler per circular inch; and $14.28 - 11.78$, or the pressure of the atmosphere $= 2.5$ lbs. effective elastic force or weight upon each circular inch of the safety valve.

EXAMPLE 3.—What is the power of a non-condensing engine, having a cylinder of 9 inches diameter, a stroke of 2 feet, or 200 feet velocity per minute, and a pressure of steam in the boiler of 40 lbs. per square inch, atmospheric pressure included, the steam to be stopped off from the piston at half stroke, and the resistance, friction, &c. 18 lbs. per square inch, or 14.1 lbs. per circular inch on the piston's area?

40 lbs. per square inch $= 31.4$ lbs. per circular inch, $\frac{24}{12} = 2$, and $\frac{31.4}{2} = 15.7$, The hyperbolic logarithm of 2, plus $1 = 1.693 \times 15.7 = 26.6$ lbs. uniform force of the steam per circular inch, and $26.6 - 14.1 = 12.5$ lbs. effective force on each circular inch of the piston;

$$\text{hence, } \frac{9^2 \times 12.5 \times 200}{33000} = 6.1 \text{ horses' power.}$$

EXAMPLE 4.—Let it be required to construct a non-condensing engine of 6.1 horses' power, the uniform elastic force of steam to be 26.6 lbs. per circular inch in the cylinder, when cut off—at half stroke, piston's velocity 200 feet per minute, resistance and friction 14.1 lbs. per circular inch; required the cylinder's diameter in inches, and also the pressure of the steam on each circular inch of the boiler above the pressure of the atmosphere.

26.6 lbs. elastic force, minus 14.1 resistance and friction, $= 12.5$ lbs. effective pressure per circular inch; hence,

$$\sqrt{\frac{33000 \times 6.1}{200 \times 12.5}} = 9 \text{ inches diameter.}$$

Again, $\frac{24}{\cdot 12} = 2$, The hyperbolic logarithm of 2 plus 1 = 1.693, and $\frac{26.6 \times 2}{1.693} = 31.4 - 11.78 = 19.62$ lbs. per circular inch, or 25 lbs. per square inch in the boiler above the pressure of the atmosphere.

The preceding may be taken as the real effect of an engine, expressed in the usual term, *horses' power;* but, there exist various nominal and approximate rules, whereby the diameter of a cylinder, or power of an engine, is determined, but governed in a great measure by competition,—one maker endeavouring to excel another, by increasing the effect of the engine and retaining the same nominal power, which is not unfrequently supposed the result of superior mechanism, or some very essential interior intricacy, although, generally, at the expense of a larger cylinder, or an increased force of steam.

However, the following are selected as those most commonly used, and what custom has rendered almost a general standard, the more so, no doubt, on account of being considered to have originated from the celebrated firm of Boulton and Watt.

In this rule the steam in the boiler is supposed at a constant pressure of about 3.18 lbs. per square inch, or 2.5 per circular inch; the piston at a constant or uniform velocity of 220 feet per minute; and the effective force on the piston about 7.5 lbs. per square inch, or 5.89 lbs. per circular inch; and under such circumstances 30 circular inches are considered an equivalent to one horse power, when the beam for communicating the motion from the piston is about 3, and the connecting rod not less than 2.5 times the length of stroke.

But marine engines are generally confined, the connecting rods being seldom more than from 1.75 to twice the length of stroke, and, as a compensation for this disadvantage, the area of the piston is augmented to 31.5 circular inches to each horse power.

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Again, small packets for rivers, &c., are still more confined, being often compelled to have the connecting rods not more than from 1.25 to 1.5 times the length of stroke, causing a very acute angle with the crank; in such, not fewer than 34 circular inches is considered equal to one horse power.

In high-pressure, or non-condensing engines, one-third the force of the steam is deducted for resistance of the atmosphere, friction, &c.; hence, as in condensing engines, $30 \times 5.89 = 176.7$ lbs. effective pressure equal the amount of one horse power; consequently, steam at 25 lbs. per square inch, or 19.63 lbs. per circular inch, minus $\frac{1}{3}$rd, $= \frac{19.63 \times 2}{3} = 13.08$ lbs. effective pressure on each circular inch of the piston's area, and $176.7 \div 13.08 = 13.6$ circular inches to each horse power.

Steam at 30 lbs. per square inch $= 23.56$ lbs. per circular inch, and $\frac{23.56 \times 2}{3} = 15.7$ lbs. effective pressure; hence, $176.7 \div 15.7 = 11.3$ circular inches to each horse power.

Steam at 40 lbs. per square inch $= 31.41$ lbs. per circular inch, and $\frac{31.41 \times 2}{3} = 20.94$ lbs. effective pressure; hence, $176.7 \div 20.94 = 8.5$ circular inches to each horse power.

Steam at 50 lbs. per square inch $= 39.27$ lbs. per circular inch, and $\frac{39.27 \times 2}{3} = 26.18$ lbs. effective pressure; hence, $176.7 \div 26.18 = 6.8$ circular inches to each horse power;—and the same at any other pressure that might be required.

Example 1.—Required the diameter of a cylinder for a land condensing engine of 36 horses' power.

$$\sqrt{36 \times 30} = 32.86 \text{ inches diameter.}$$

Example 2.—What is the nominal power of an engine, the cylinder of which is 32.86 inches diameter?

$$32.86^2 \div 30 = 36 \text{ horses' power.}$$

Example 3.—Required the diameter of the cylinder for a marine engine of 65 horses' power.

$$\sqrt{65 \times 31.5} = 45.25 \text{ inches diameter.}$$

Example 4.—The diameter of the cylinder of a marine engine is 45.25 inches diameter; required the nominal power of the engine.

$$45.25^2 \div 31.5 = 65 \text{ horses' power.}$$

Example 5.—The force of the steam in a boiler is 30 lbs. per square inch above the pressure of the atmosphere; if it were applied to a non-condensing engine, so as to produce a power equal to 6 horses, what must be the cylinder's diameter?

$$\sqrt{11.3 \times 6} = 8.25 \text{ inches diameter.}$$

Example 6.—The diameter of the cylinder of a non-condensing engine is 8.25 inches, and the steam at 30 lbs. per square inch, required the engine's power.

$$8.25^2 \div 11.3 = 6 \text{ horses' power.}$$

A Table containing the difference between a certain elastic force of steam on a square and circular inch.

Steam with an elastic force of	lbs. on a square inch, equal	lbs. on a circular inch, and require to be maintained at a temperature of		Steam with an elastic force of	lbs. on a circular inch, equal	lbs. on a square inch, and require to be maintained at a temperature of
2.5	1.96	220° F		2.5	3.18	222.5° F
3	2.35	222		3	3.82	224.5
3.5	2.75	223.5		3.5	4.45	226.5
4	3.14	225		4	5.09	228.5
4.5	3.53	227		4.5	5.73	230.5
5	3 92	228		5	6.36	232
5.5	4.32	230		5.5	7.00	234
6	4.71	231.5		6	7.64	235.5
6.5	5.10	233		6.5	8.27	236.5
7	5.49	234		7	8.91	238.5
7.5	5.89	235		7.5	9.55	239.5
8	6.28	236		8	10.18	241
9	7.06	239		9	11.45	244
10	7.85	240		10	12.73	247
12	9.42	245.5		12	15.27	252.5
15	11.78	251		15	19.09	259
20	15.71	260		20	25.46	270
25	19.63	268		25	31.83	278.5
30	23.56	275		30	38.19	287
35	27.49	282		35	44.56	294
40	31.41	288		40	50.92	300.5
45	35.34	294		45	57.20	305
50	39.27	299		50	63.66	309

The preceding questions are very conveniently obtained by the sliding rule.

1. By the engineer's improved sliding rule.—Set 1 upon B to the number of circular inches allowed to a horse power upon A, and against the number of horses' power upon C is the cylinder's diameter in inches upon D; or, against the cylinder's diameter in inches upon D is the number of horses' power upon C.

Thus, set 1 upon B to 30 upon A, and against any number of horses' power upon C is the diameter in inches upon D, for common condensing engines.

2. By the common sliding rule.—Set 1 upon C to the diameter of a cylinder equal to 1 horse power upon D, and against any diameter upon D is the number of horses' power upon C; or, against any number of horses' power upon C is the diam. of the cylinder in in. upon D.

NOTE.—The square root of *any number* of circular inches to a horse power equal *the diameter*;—thus $\sqrt{30} = 5.47$ inches,—$\sqrt{31} = 5.6$ inches,—$\sqrt{34} = 5.8$ inches, being the diameters of cylinders of 1 horse power, for land and marine condensing engines; And $\sqrt{13.6} = 3.7$ inches,—$\sqrt{11.3} = 3.4$ inches,—$\sqrt{8.5} = 2.9$ inches,—and $\sqrt{6.8} = 2.6$ inches, or the diameter of cylinders for non-condensing engines of 1 horse power, with steam above the pressure of the atmosphere equal to 25, 30, 40, and 50 lbs. per square inch.

EXAMPLE 1.—What diameter must a cylinder be for a condensing engine to equal 20 horses' power?

Set 1 upon B to 30 upon A, and against 20 upon C is $24\frac{1}{2}$ upon D.

When the rule is thus set, C is a line of horses' power, and D a line of diameters for cylinders corresponding to that power.

EXAMPLE 2.—What number of horses' power will a high pressure engine be equal to when the cylinder is 12 inches diameter, and steam 30 lbs. per square inch?

Set 1 on B to 11.3 upon A, and against 12 upon D is 12.7 horses' power upon C.

Suppose the same to be required upon the common slide rule.

1.—Set 1 upon C to 5.47 upon D, and against 20 upon C is 24½ upon D.

2.—Set 1 upon C to 3.4 upon D, and against 12 upon D is 12.7 upon C.

The following tables exhibit various proportions for engines, estimated according to their nominal power.

Table 1.—*Land Condensing Engines.*

Number of horses' power.	Diameter of cylinder in inches.	Area of apertures to the cylinder in inches.	Proportionate length of stroke in feet and in. for portable engines.	Proportionate length of stroke in feet and inches for fixed engines.	Number of strokes per minute.	Diameter of air pump in inches.	Diameter of cold water pump in inch. at ½ stroke.	Diameter of feed pump in inches at ½ stroke.	Cubic feet of water per hour for condensation.	Lbs. of good coal required per hour.
4	12	5	2 ft. 0 in	– ft. – in	55	8	3¼	1⅝	56	56
5	13¼	6	2 6	———	44	8¾	3¾	2¼	75	65
6	14¼	7	———	3 0	37	9½	4¼	2⅜	90	74
8	16¼	9	3 0	———	37	10¾	4⅝	2½	113	90
10	18	11	———	3 6	32	12	5	2⅝	158	102
12	19½	13	3 6	4 0	28	13	5⅝	2⅞	187	120
14	21	15	———	4 6	25	14	6	3	226	128
16	22½	17	4 0	———	28	15	6½	3¼	264	144
18	23½	19	———	5 0	22	15¾	6¾	3⅜	302	158
20	24½	21	———	———	22	16¼	7	3⅝	338	170
22	26	23	4 6	———	25	17¼	7¼	3¾	380	186
24	27	24	———	5 6	20	18	7¾	3⅞	420	190
25	27½	25	———	———	20	18¼	7⅞	4⅛	450	200
26	28	26	5 0	6 0	19	18½	8	4¼	480	212
28	29	28	———	———	19	19¼	8¼	4½	520	220
30	30	30	———	———	19	20	8¾	4⅝	560	236
35	32½	35	———	6 6	17	21¾	9½	4⅞	712	268
40	34½	40	———	———	17	23	10	5⅛	940	292
50	38½	50	———	7 0	16	25¾	11¼	5¾	1120	346
60	42¼	60	———	———	16	28	12	6	1225	408

NOTE.—When the fly wheel shaft is of cast iron, the diameter of the bearings is the same as the diameter of the cold water pump.

Table 2.—Marine Engines.

ENGINES WHOSE CONNECTING RODS ARE NOT LESS THAN 1⅔ TIMES THE LENGTH OF STROKE.			ENGINES WHOSE CONNECTING RODS ARE LESS THAN 1⅔ TIMES THE LENGTH OF STROKE.		
Number of horses' power.	Diameter of cylinder in inches.	Diameter of air pump in inches.	Number of horses' power.	Diameter of cylinder in inches.	Diameter of air pump in inches.
25	28	16	10	18½	12
30	30¾	17⅞	12	20¼	13¼
35	33¼	19⅛	14	22	14⅜
40	35½	20½	15	22⅝	14¾
45	37⅞	21¾	16	23½	15⅝
50	39⅝	22¾	18	24¾	16⅛
55	41¾	24	20	26	17
60	43½	25	25	29¼	19⅛
65	45¼	26	30	32	21
70	47	27	35	34½	22½
75	48¾	28	40	37	24⅛
80	50¼	29	45	39¼	25⅝
85	51¾	29¾	50	41¼	27
90	53¼	30⅝			
95	54¾	31½			
100	56¼	32⅞			
110	59	34			
120	61½	35⅜			
130	64	37			
150	68¾	39½			
200	79½	45⅝			

Table 3.—Non-condensing or High-pressure Engines.

Number of horses' power.	Diameter of cylinder in inches,—steam at 25 lbs. per square inch.	Diameter of cylinder in inches,—steam at 30 lbs. per square inch.	Diameter of cylinder in inches,—steam at 40 lbs. per square inch.	Diameter of cylinder in inches,—steam at 50 lbs. per square inch.
1	3¾	3½	3	2⅝
2	5¼	4¾	4¼	3¾
3	6½	6	5	4½
4	7½	6¾	6	5¼
6	9	8¼	7¼	6½
8	10½	9¾	8½	7½
10	11¾	11	9½	8⅞
12	13	12	10⅞	9¼
14	14	12¾	11¼	10
16	15	13¾	12	10½
18	15¾	14½	12¾	11¼
20	16¾	15¼	13⅜	11¾
25	18½	17¼	15	13¼
30	20¼	19¾	16¼	14½
Quantity of water in gallons per minute to each horse power,	.45	.5	.61	.73

Suppose the same to be required upon the common slide rule.

1.—Set 1 upon C to 5.47 upon D, and against 20 upon C is $24\frac{1}{2}$ upon D.

2.—Set 1 upon C to 3.4 upon D, and against 12 upon D is 12.7 upon C.

The following tables exhibit various proportions for engines, estimated according to their nominal power.

Table 1.—*Land Condensing Engines.*

Number of horses' power.	Diameter of cylinder in inches.	Area of apertures to the cylinder in inches.	Proportionate length of stroke in feet and in. for portable engines.	Proportionate length of stroke in feet and inches for fixed engines.	Number of strokes per minute.	Diameter of air pump in inches.	Diameter of cold water pump in inch. at ½ stroke.	Diameter of feed pump in inches at ¼ stroke.	Cubic feet of water per hour for condensation.	Lbs. of good coal required per hour.
4	12	5	2*ft.* 0*in*	–*ft.* –*in*	55	8	$3\frac{1}{4}$	$1\frac{7}{8}$	56	56
5	$13\frac{1}{4}$	6	2 6	——	44	$8\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{1}{4}$	75	65
6	$14\frac{1}{4}$	7	——	3 0	37	$9\frac{1}{2}$	$4\frac{1}{4}$	$2\frac{3}{8}$	90	74
8	$16\frac{1}{4}$	9	3 0	——	37	$10\frac{3}{4}$	$4\frac{5}{8}$	$2\frac{1}{2}$	113	90
10	18	11	——	3 6	32	12	5	$2\frac{5}{8}$	158	102
12	$19\frac{1}{2}$	13	3 6	4 0	28	13	$5\frac{5}{8}$	$2\frac{7}{8}$	187	120
14	21	15	——	4 6	25	14	6	3	226	128
16	$22\frac{1}{2}$	17	4 0	——	28	15	$6\frac{1}{2}$	$3\frac{1}{4}$	264	144
18	$23\frac{1}{2}$	19	——	5 0	22	$15\frac{3}{4}$	$6\frac{3}{4}$	$3\frac{3}{8}$	302	158
20	$24\frac{1}{2}$	21	——	——	22	$16\frac{1}{2}$	7	$3\frac{1}{2}$	338	170
22	26	23	4 6	——	25	$17\frac{1}{4}$	$7\frac{1}{4}$	$3\frac{5}{8}$	380	186
24	27	24	——	5 6	20	18	$7\frac{3}{4}$	$3\frac{7}{8}$	420	190
25	$27\frac{1}{2}$	25	——	——	20	$18\frac{1}{4}$	$7\frac{7}{8}$	$4\frac{1}{8}$	450	200
26	28	26	5 0	6 0	19	$18\frac{1}{2}$	8	$4\frac{1}{4}$	480	212
28	29	28	——	——	19	$19\frac{1}{4}$	$8\frac{1}{4}$	$4\frac{1}{2}$	520	220
30	30	30	——	——	19	20	$8\frac{3}{4}$	$4\frac{5}{8}$	560	236
35	$32\frac{1}{2}$	35	——	6 6	17	$21\frac{3}{4}$	$9\frac{1}{2}$	$4\frac{7}{8}$	712	268
40	$34\frac{1}{2}$	40	——	——	17	23	10	$5\frac{1}{8}$	940	292
50	$38\frac{1}{2}$	50	——	7 0	16	$25\frac{3}{4}$	$11\frac{1}{4}$	$5\frac{5}{8}$	1120	346
60	$42\frac{1}{2}$	60	——	——	16	28	12	6	1225	408

NOTE.—When the fly wheel sha[illegible] diameter of the bearings is the same as the diamet[illegible]

To ascertain the power or effect of a locomotive engine.

The efficiency of a locomotive engine depends upon the *force* of the steam, the *area* of the cylinders, and the *ratio* existing between the length of the stroke and the diameter of the wheels; also, the resistance of the *atmosphere*, and *friction* of the engine, which is on an average 15 lbs. per ton;—hence, by the following simple formula, the various effective proportions may be determined, and also the amount of useful effect produced from a certain given force of steam.

Let W represent the weight of the load in gross tons, tender included,

- 9 ....resistance of the load per ton,
- F or 15 ......resistance and friction of the engine per ton,
- D ....diameter of the wheels in feet,
- *d* ....diameter of the cylinders in feet, or parts of a foot,
- *l* ....length of stroke, also in feet or parts of a foot,
- P ....total pressure of steam in the boiler per square foot, atmospheric pressure included,
- *p* ....atmospheric pressure per sqr. foot, or 2117 lbs.: hence, $P - p =$ the effective pressure,
- S ....quantity of water evaporated per hour in cubic feet,
- *r* ....ratio of the volume of steam, water being 1, or the volume of steam to the volume of water that produced it,

And V ....velocity of the engine in feet per hour.

1. $\dfrac{P\,r\,S\,D - p\,d^2\,l\,V}{V\,9\,D} - \dfrac{F}{9} = W$, or the load in gross tons, tender included, that a given engine will *draw, with* a known pressure and a determined velocity.

2. $$\frac{(P-p)\,d^2\,l}{9\,D} - \frac{F}{9} = W,$$ or the maximum weight that an engine is able to draw at a determined pressure, in gross tons, tender included.

3. $$\sqrt{\frac{D\,(9\,W + F)}{(P-p)\,l}} = d,$$ or the cylinder's diameter in feet or parts of a foot, in order that, if necessary, it may draw a certain maximum load.

4. $$\frac{D\,(9\,W + F)}{(P-p)\,d^2} = l,$$ or the length of stroke in feet, so that a proper ratio may exist between the stroke and the wheels, to enable the engine to produce the same effect of maximum load.

5. $$\frac{(P-p)\,d^2\,l}{9\,W + F} = D,$$ or the diameter of the wheels that an engine must have in order to render it able to draw a fixed or maximum load.

To illustrate the preceding formula by example,—Suppose an engine of the following proportions :—

Diameter of cylinders 11 inches, or .917 feet,
Length of stroke 16 inches, or 1.33 feet,
Diameter of wheels 5 feet,
Weight of engine 8 tons,
Quantity of water evaporated per hour, 38.74 cubic feet,
And Effective pressure 50 lbs. per square inch; what are the various effects and proportions, as might be required?

In the present case,

$P = 144 \times 65 = 9360$ lbs., or the pressure of steam per square foot, atmospheric pressure included,

$p = 2117$ lbs., or the pressure of the atmosphere per square foot, and

$P - p = 7243$ lbs. effective pressure per square foot,

$F = 15 \times 8 = 120$, or the resistance and friction of the engine, and

$r = 435$ (*see Table, page* 20.) Hence,

Ex. 1. Required the load an engine of this description will take upon a level, at the rate of 20 miles per hour.

20 miles = 105600 feet, then

$$\frac{144 \times 65 \times 435 \times 38.74 \times 5 - 2117^2 \times .917 \times 1.33 \times 105600}{105600 \times 9 \times 5} =$$

$$113.13 - \frac{120}{9} = 100 \text{ tons gross weight, tender included.}$$

Ex. 2. What is the maximum load for an engine of the preceding proportions, and steam at 50 lbs. per square inch, effective pressure?

$$\frac{\overline{9360 - 2117} \times .917^2 \times 1.33}{9 \times 5} = 180 - \frac{120}{9} = 166.7$$

tons gross weight.

Ex. 3. What must be the diameter of the cylinders for a locomotive engine as above, so that it may be enabled to draw a load of 166.7 tons?

$$\sqrt{\frac{166.7 \times 9 + 120 \times 5}{9360 - 2117 \times 1.33}} = .917 \text{ of a foot, or } 11$$

inches diameter.

Ex. 4. Required the length of stroke, so as to render

this engine capable of drawing 166.7 tons, with wheels of 5 feet diameter.

$$\frac{166.7 \times 9 + 120 \times 5}{9360 - 2117 \times .917^2} = 1.33 \text{ feet, or 16 inches, length}$$
of stroke.

Ex. 5.—What must be the diameter of the wheels for a locomotive engine, in order that it may be able to draw a given maximum load, the other proportions being the same as above?

$$\frac{9360 - 2117 \times .917^2 \times 1.33}{166.7 \times 9 + 8 \times 15} = 5 \text{ feet diameter.}$$

The following table contains the diameters of cylinders, with a given pressure of steam, to draw certain maximum loads :—

Particulars of the Engine.	Load in gross tons tender included.	Diameter of Cylinders in inches, with steam at 50lbs. 55lbs. & 60lbs. per sq. inch in the boiler.		
Wheels 5 feet. Stroke 16 inches, or 1.33 feet. Weight 8 to 10 tons.	100	9 in.	8½ in	8 in.
	125	9¾	9¼	9
	150	10½	10	9⅝
	175	11¼	11	10¼
	200	12	11½	11
	225	12¾	12⅛	11⅝
	250	13½	12¾	12¼
Wheels 5 feet. Stroke 16 inches, or 1.33 feet. Weight 10 to 12 tons.	200	12¼	11⅝	11¼
	225	13	12¼	12
	250	13½	13	12¼
	275	14⅛	13½	13
	300	14¾	14	13½
	325	15¼	14⅝	14
	350	16	15⅛	14½
Wheels 5 feet. Stroke 18 inches, or 1.5 feet. Weight 11 to 13 tons.	200	11½	11	10½
	225	12⅛	11½	11
	250	12¾	12⅛	11⅝
	275	13¼	12¾	12⅛
	300	14	13¼	12⅝
	325	14½	13¾	13⅛
	350	15	14¼	13⅝

THE NOZZLES, FRONT PIPES, OR SLIDE VALVES,

Are for the purpose of alternate admission of steam to and from the cylinder of a steam-engine, and consist of either *conical valves*, *slide valves*, or *cocks*, the motion of which is derived from the engine by various means, as *tappets*, *eccentrics*, *cambs*, &c., and by such means various effects are produced; however, practice has sufficiently decided the superiority to tappets, or hand gear, as the means by which the most effective power of an engine can be obtained,—but their unpleasant noise and greater liability of derangement prevent their more frequent application; hence, to render the eccentric more effective, the *apertures* or steam openings to the cylinder are of a certain proportion, and made as long as the cylinder's diameter will properly admit, so that by a smaller movement of the valve a greater opening may be gained. In condensing engines the area of each opening or steam way equal $\frac{1}{30}$th, and non-condensing or high-pressure engines $\frac{1}{16}$th of the square of the cylinder's diameter.

And, as a farther means of enabling the eccentric to approximate hand gear, the valve or valves are placed at a certain distance in advance of the piston, and termed by engineers *the lead of the valve*, so that at each return of stroke the steam in the cylinder may sooner approach an equal density to the steam in the boiler; but an excess of lead is only advantageous to engines lightly loaded, and an increased velocity required. When such is the case, a proper impulse of steam at the commencement of the stroke, and again sooner cut off, is of considerably more advantage than steam gradually applied, and in a similar way continued to the end of the stroke; hence, the propriety of lead for the valves of engines on board steam-packets for carrying *passengers;* and also the valves of locomotive engines for running

passenger trains, &c., for the velocity is increased in nearly the following proportion :—

When the lead of the valve is	0	the velocity	= 1.
....	$\frac{1}{8}$ inch	....	= 1.016.
....	$\frac{3}{8}$	....	= 1.048.
....	$\frac{5}{8}$	....	= 1.103.

But by such means the maximum effect of an engine may be considerably lessened, for it is the pressure and quantity of steam which constitute the power, and in proportion as the lead of the valve is increased so is the length of stroke, or quantity of steam diminished by being sooner cut off,—consequently, the power of the engine reduced; for which reason, other means are frequently resorted to, whereby to effect a greater advantage of the steam during the stroke, otherwise than by the lead of the valve. Among the most practical for that purpose is the *camb* or *tumbler*, a modification of which has been recently and successfully applied to a locomotive engine on the Leeds and Selby Railway, by Mr. Hope, engineer for that department; and by this arrangement not only is a greater extent of power obtained, but on a railway accidents may in a great measure be prevented, by a sudden application of the steam for reversing the motion of the engine, even at its greatest velocity, and without the smallest uncertainty or liability to derangement by a complication of machinery.

In order further to illustrate the advantage and disadvantage to an engine by the lead of the valve, the following table is annexed, as the result of experiments on the Liverpool and Manchester Railway, by C. de Pambour, and which I find in practice nearly to coincide :—

F 2

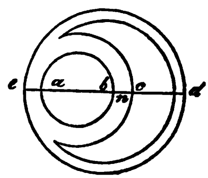
Particulars of the Engine.	Load in gross tons tender included	Velocity in miles per hour, the lead of the valve being			
		0	⅛ in.	⅜ in.	⅝ in.
	tons.	miles.	miles.	miles.	miles.
Diameter of cylinders 11 in.	50	31.02	31.52	32.51	34.23
Stroke 16 inches.	100	21.68	22.02	22.72	23.92
Wheels 5 feet.	141	17.39	17.66	18.22	19.18
Effective pressure 50 lbs.	155	16.28	16.54	17.06	0.
per square inch.	163	15.72	15.96	0.	0.
	165	15.58	0.	0.	0.
	50	27.80	28.24	29.13	30.68
Diameter of cylinders 12 in.	100	20.05	20.37	21.01	22.12
Stroke 16 inches.	150	15.68	15.93	16.43	17.30
Wheels 5 feet.	168	14.56	14.79	15.25	16.06
Effective pressure 50 lbs.	183	13.72	13.94	14.38	0.
per square inch.	193	13.22	13.43	0.	0.
	196	13.11	0.	0.	0.
	50	26.16	26.57	27.41	28.86
Diameter of cylinders 12 in.	100	19.85	20.16	20.80	21.90
Stroke 18 inches.	150	15.99	16.24	16.75	17.64
Wheels 5 feet.	188	13.93	14.15	14.60	15.37
Effective pressure 50 lbs.	207	13.09	13.30	13.72	0.
per square inch.	217	12.69	12.89	0.	0.
	221	12.53	0.	0.	0.

Again, *the lap or cover of the valve* is a certain additional breadth of its face on the steam side, more than the width of the aperture to the cylinder, for the purpose of cutting off the steam at any determined part of the stroke, and which is of considerable advantage in condensing engines when steam of greater elastic force is employed than is necessary to be continued throughout the whole stroke. In our present practice, the lap for land engines is from ½ inch to ⅝, with steam of 3½ to 4 lbs. per square inch above the pressure of the atmosphere. But the lap for marine engines varies from ⅜ to 1¾ inches, according to the elastic force of the steam, ranging from 4 to 10 lbs. per square inch,—for the calculated advantage of which *see page* 45. Locomotive engines and non-condensing engines, in general, with short strokes, require no more lap than just perceptibly covers the apertures to the cylinder when the valve is at the middle of the stroke.

ECCENTRICS, CAMBS, &c.

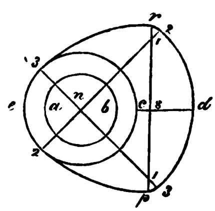
An *eccentric* is a contrivance by which continued circular motion is converted into alternate rectilinear motion; and, in like manner, by the *camb*, is uniform rotatory motion converted to a varied rectilinear motion; hence, their frequent application in the steam-engine for giving motion to the valves, whereby the direction of the steam is alternately changed, and also the quantity regularly proportioned.

1. *To construct an eccentric of the usual form for a steam-engine.*



Upon a straight line with the radius of the shaft describe the circle or eye of the eccentric, *a b;* describe, also, the circle *e c*, or necessary thickness of metal around the shaft, for the boss; make *c* to *d* equal the travel of the valve or required throw of the eccentric; bisect *e d* in *n*, and form *n* as a centre, with the radious *n e* or *n d*, describe the diameter of the eccentric as required.

2. *To construct a camb as applicable to the steam-engine.*



Describe the circle *a b* equal to the diameter of the shaft on which it is to be fixed; also, the circle *e c*, or thickness of metal round the shaft by which it is to be fixed; make *c d* equal to the travel of the valve or required throw of the camb; draw the line *p r* at right angles with the line *c d*, and distant from *d* three-fourths of the radius *e n* or *n c;* bisect *e d*, and with the same distance from where the lines intersect each other set off *s p* and *s r*; on the line *p r*, with one-fourth of the radius *e n* or *n c*, set off *p* 1 and *r* 1; draw the lines 2 2

and 3 3; from 1, with the radius 1 r, describe r 2 and p 3; also, from 1, with the distance 1 3, describe 3 r and 2 p, and from n, with the distance n d, describe 2 d 3, which constitute the camb required.

But the throw of the eccentric in a steam engine is not particularly required to equal the travel of the valve, for the direction of the motion generally requires to be changed by levers, which may be made unequal lengths at pleasure.

Hence, let t represent the travel of the valve,
L ...... the length of the lever to which the eccentric rod is attached,
E ...... the throw of the eccentric,
And l ...... the length of the lever for giving motion to the valve;

Then, 1. $\frac{t\,L}{l} = E.$ 2. $\frac{t\,L}{E} = l.$ 3. $\frac{E\,l}{t} = L.$ 4. $\frac{E\,l}{L} = t.$

EXAMPLE.—Suppose $t = 8$ inches.
$L = 6$ „
$E = 4$ „
$l = 12$ „

1. $\frac{8 \times 6}{12} = 4$ inches, throw of eccentric.

2. $\frac{8 \times 6}{4} = 12$ inches, length of lever for giving motion to the valve.

3. $\frac{4 \times 12}{8} = 6$ inches, length of lever at the end of eccentric rod.

4. $\frac{4 \times 12}{6} = 8$ inches, or the travel of the valve.

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THE CONDENSER, COLD WATER PUMP, AND AIR PUMP.

When steam is exposed to any degree of cold its heat is abstracted,—its elastic force diminished; and, in proportion to the intensity or quantity of cold, is sooner or later condensed, and re-assumes the state of water, by which its bulk is reduced nearly 2000 times. Hence the principal property in the condensing engine.

Various means have been employed whereby condensation might sooner be effected in the steam-engine, and a more perfect vacuum obtained, but nothing as yet have superseded a jet of cold water, hence the necessity of a condenser and air pump in marine engines, and also the necessity for a condenser, cold water pump, and an air pump in land engines generally.

The capacity of the condenser ought to be as large as circumstances will conveniently admit, and not less than one-eighth the capacity of the cylinder; but, in marine engines, where the bottom of the condenser and bottom of the cylinder are on nearly the same line, care must be taken in making the passage between the valves and condenser large enough to contain the condensing water required for one stroke of the piston, besides leaving a proper communication, otherwise the connexion between the cylinder and air pump will be cut off by water of nearly 100° of heat, on account of the cylinder being twice filled with steam for each effective stroke of the air pump.

To produce the greatest effect in an engine the condensed water ought never to exceed 100° Ft., and to obtain this point requires about 30 cubic inches of water at a mean temperature of the atmosphere for every cubic foot of steam at 220°, to which point it is generally reduced or expanded; but, in calculating for the capacity of the cold water pump, an additional quantity must be annexed for imperfections, uncertainty of tem-

perature, &c.; hence, not less than 35 cubic inches, or 45 circular inches, is considered sufficient; and as the pump makes only one effective stroke while the piston makes two, twice the length of stroke multiplied by the area is taken for the cylinder's capacity.

Then suppose
A = the area of the cylinder in feet,
S = twice the length of stroke also in feet,
45 circular inches the quantity of water to each cubic foot of steam,
l = the stroke of the pump in inches,
And d = the diameter of the pump in inches,

Then $\sqrt{\dfrac{A\ S\ 45}{l}} = d.$ and $\dfrac{A\ S\ 45}{d^2} = l.$

EXAMPLE.—What diameter of pump is necessary for an engine with a cylinder 30 inches, or $2\frac{1}{2}$ feet diameter, stroke 6 feet, and the stroke of the pump to equal half the stroke of the engine, or 36 inches?
Area of cylinder = 4.9 feet. Stroke $\times$ 2 = 12 feet.

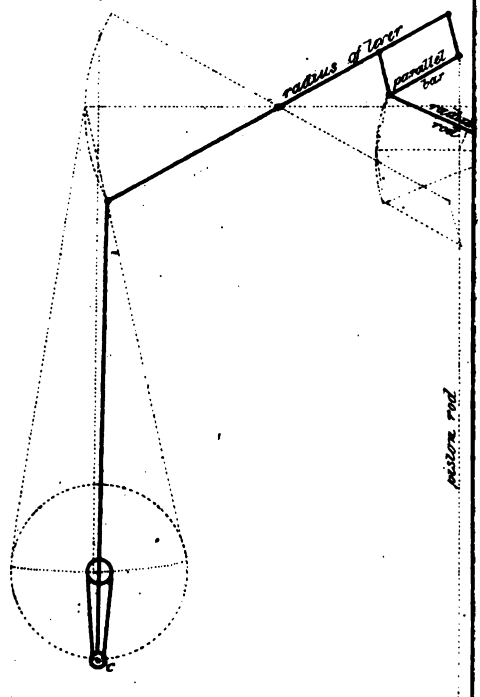
$$\sqrt{\frac{4.9 \times 12 \times 45}{36}} = 8.25 \text{ inches diameter.}$$

And $\dfrac{4.9 \times 12 \times 45}{8.55} = 36$ inches length of stroke.

Again, the *air pump* is for the purpose of extracting or emptying the condenser of water, uncondensed steam, air, &c., which accumulate in the act of condensation. Its capacity in land engines is about $\frac{1}{4}$th the capacity of the cylinder, and in marine engines $\frac{1}{5}$th. Hence, suppose the cylinder of a land engine equal 20 inches diameter, stroke 4 feet, or 48 inches; required the air pump's diameter at half stroke.

$$\frac{20^2 \times 48}{4 \times 24} = \sqrt{200} = 14.14 \text{ inches diameter.}$$

Fig 1st. A motion that is generally applie
Land Engines &c.



Or, required the diameter of air pump for a marine engine with a cylinder 36 inches diameter, stroke $3\frac{1}{2}$ feet, and the studs by which the pump bucket is to be worked placed 36 inches from the ends of the levers, the radius, or half length of the levers, being 5 feet.

Radius of beams or levers 60 inches, stroke 42 inches,
Radius of pump studs 24 inches,

Then, as

$60 : 42 :: 24 : 16.8$ inches, or stroke of the pump.

And $\dfrac{36^2 \times 42}{5 \times 16.8} = \sqrt{648} = 25.48$ inches diameter.

THE PARALLEL MOTION, BEAM, &c.

In a *beam engine* the parallel motion is the link or connexion between the top of the piston rod and end of the beam, and also the means by which the piston rod is made to move in a direct line; hence, according as the beam is differently situated in the engine, so must the motion be differently modified to suit—*(see Table of Parallel Motions)*—but in whatever situation the beam or levers may be placed the principle of the motion remains the same, and its correctness depends entirely upon the radius rods being of a proper length, which may be obtained by the following general rule:—

Let R = the radius of the beam,
l = „ length of parallel bars,
And r = „ length of radius rods,

Then $$\frac{\overline{R - l}^2}{l} = r$$

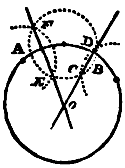
Example.—Suppose the radius of a beam equal $6\frac{1}{2}$ feet, or 78 inches, and the length of the parallel bars 34 inches; required the length of radius rods.

$78 - 34 = 44$, and $\dfrac{44^2}{34} = 56.35$ inches.

But in marine engines, or engines on the marine principle, the side rods constitute the front links of the motion, having the parallel bars frequently attached at some distance below the end of the cross head—(*see Figure* 3, *Table of Motions,*)—by which different angles are formed, and the preceding rule rendered incorrect. Other suitable rules might be applied, but being, in general, much more tedious, it is better to lay it down in the following geometrical form :—

See Fig. 3.—Upon the line A *m*, with the radius of the beam, describe the arc *b m t;* from *m*, with half the length of stroke, cut the arc in *b* and *t*, draw the line *b t* and *r m* equal the versed sine described by the beam; bisect *r m* in *n*, and erect a perpendicular line for the centre of the cylinder. Again, from *b m t*, with the length of the side rods, cut the perpendicular line; at the bottom, middle, and top stroke of the cross-head draw the lines *b b*, *m m*, and *t t;* from the end of the cross-head, or top of the side rods, with any convenient distance, set off the pin or stud in the side rod for the end of the parallel bar 1, 2, 3, from which, with the distance *s t*, describe arcs at *d* D *d*; draw the lines *d* 1, D 2, &c.; also, with the distance *m* 2, from S S S, cut the former arcs in *d* D *d*, and the radius of the circle, or length of the radius rod, D *k*, is found by the following problem :—

Through any three points out of a right line to describe the circumference of a circle.



From the middle point as a centre, with any convenient distance, describe the circle, or arcs of a circle, as A and B, and from the other points, with the same distance, describe arcs cutting the circle in C D and E F; draw lines through C D and E F, and where they intersect each other at *o* is the centre of the circle required.

A Table containing the length of radius rods for motions with beams and parallel bars of various lengths.

Radius of beam in Ft. & In.		Length of parallel bars in Ft. & In.		Length of radius rods in Ft. & In.	
4	0	1	6	4	2
..	..	1	9	2	10¾
..	..	2	0	2	0
..	..	2	3	1	4⅜
..	..	2	6	0	10⅞
..	..	2	9	0	6⅞
..	..	3	0	0	4
4	6	1	6	6	0
..	..	1	9	4	3⅞
..	..	2	0	3	1½
..	..	2	3	2	3
..	..	2	6	1	7¼
..	..	2	9	1	1⅜
..	..	3	0	0	9
..	..	3	3	0	5¾
5	0	1	6	8	2
..	..	1	9	6	0½
..	..	2	0	4	6
..	..	2	3	3	4⅜
..	..	2	6	2	6
..	..	2	9	1	10⅛
..	..	3	0	1	4
..	..	3	3	0	11¼
..	..	3	6	0	7¾
5	6	1	6	10	8
..	..	1	9	8	0⅜
..	..	2	0	6	1½
..	..	2	3	4	8⅜
..	..	2	6	3	7¼
..	..	2	9	2	9
..	..	3	0	2	1
..	..	3	3	1	6⅜
..	..	3	6	1	1¾
..	..	3	9	0	9⅞
6	0	2	0	8	0
..	..	2	3	6	3
..	..	2	6	4	10¾
..	..	2	9	3	10
..	..	3	0	3	0
..	..	3	3	2	3⅞
..	..	3	6	1	9½
..	..	3	9	1	4¼
..	..	4	0	1	0
..	..	4	3	0	8½
6	6	2	0	10	1½
..	..	2	3	8	0
..	..	2	6	6	4¾
6	6	2	9	5	1⅜
..	..	3	0	4	1⅛
..	..	3	3	3	3
..	..	3	6	2	6⅞
..	..	3	9	2	0¼
..	..	4	0	1	6¾
..	..	4	3	1	2¼
..	..	4	6	0	10½
7	0	2	0	12	6
..	..	2	3	10	0¼
..	..	2	6	8	1¼
..	..	2	9	6	7
..	..	3	0	5	4
..	..	3	3	4	4
..	..	3	6	3	6
..	..	3	9	3	2⅞
..	..	4	0	2	3
..	..	4	3	1	9
..	..	4	6	1	4⅝
..	..	4	9	1	0⅛
..	..	5	0	0	9⅝
7	6	2	0	15	1½
..	..	2	3	12	3
..	..	2	6	10	0
..	..	2	9	8	2⅜
..	..	3	0	6	9
..	..	3	3	5	6¾
..	..	3	6	4	6⅞
..	..	3	9	3	9
..	..	4	0	3	0¾
..	..	4	3	2	6
..	..	4	6	2	0
..	..	4	9	1	7
..	..	5	0	1	3
..	..	5	3	0	11½
8	0	2	6	12	1¼
..	..	2	9	10	0¾
..	..	3	0	8	4
..	..	3	3	6	11¼
..	..	3	6	5	9½
..	..	3	9	4	9¾
..	..	4	0	4	0
..	..	4	3	3	3¾
..	..	4	6	2	8⅜
..	..	4	9	2	2¾
..	..	5	0	1	9⅝
..	..	5	3	1	5¼
..	..	5	6	1	1⅛

A Table containing the length of radius rods for motions with beams and parallel bars of various lengths.

(CONTINUED.

Radius of beam in Ft.	& In.	Length of parallel bars in Ft.	& In.	Length of radius rods in Ft.	& In.
8	6	3	0	10	1
..	..	3	3	8	5¾
..	..	3	6	7	1¾
..	..	3	9	6	0¼
..	..	4	0	5	6¾
..	..	4	3	4	3
..	..	4	6	3	6⅝
..	..	4	9	2	11½
..	..	5	0	2	5⅝
..	..	5	3	2	0⅛
..	..	5	6	1	7⅜
..	..	5	9	1	3⅝
..	..	6	0	1	0½
9	0	3	0	12	0
..	..	3	3	10	2
..	..	3	6	8	7¾
..	..	3	9	7	4¼
..	..	4	0	6	3
..	..	4	3	5	3¾
..	..	4	6	4	6
..	..	4	9	3	9⅝
..	..	5	0	3	2½
..	..	5	3	2	8⅛
..	..	5	6	2	2¾
..	..	5	9	1	10
..	..	6	0	1	6
..	..	6	3	1	2½
9	6	3	6	10	3½
..	..	3	9	8	9⅞
..	..	4	0	7	6¾
..	..	4	3	6	5⅞
..	..	4	6	5	6⅝
..	..	4	9	4	9
..	..	5	0	4	0⅝
..	..	5	3	3	5⅝
..	..	5	6	2	10⅞
..	..	5	9	2	5¼
..	..	6	0	2	0½
..	..	6	3	1	8¼
10	0	4	0	9	0
..	..	4	3	7	9⅜
..	..	4	6	6	8⅝
..	..	4	9	5	9½
..	..	5	0	5	0
..	..	5	3	4	3½
..	..	5	6	3	8⅛
..	..	5	9	3	1¾
..	..	6	0	2	8
..	..	6	3	2	3
..	..	6	6	1	10½
10	6	4	0	10	6¾
..	..	4	3	9	2¼
..	..	4	6	8	0
..	..	4	9	6	11½
..	..	5	0	6	0½
..	..	5	3	5	3
..	..	5	6	4	6½
..	..	5	9	3	11
..	..	6	0	3	3¼
..	..	6	3	2	10⅜
..	..	6	6	2	5⅝
..	..	6	9	2	1
..	..	7	0	1	9
11	0	4	6	9	4⅝
..	..	4	9	8	2¾
..	..	5	0	7	2½
..	..	5	3	6	3½
..	..	5	6	5	6
..	..	5	9	4	9½
..	..	6	0	4	2
..	..	6	3	3	7⅜
..	..	6	6	3	1⅝
..	..	6	9	2	8⅛
..	..	7	0	2	3½
11	6	4	6	10	10⅝
..	..	4	9	9	7
..	..	5	0	8	5½
..	..	5	3	7	5¼
..	..	5	6	6	6½
..	..	5	9	5	9
..	..	6	0	5	0½
..	..	6	3	4	5
..	..	6	6	3	10⅛
..	..	6	9	3	4
..	..	7	0	2	10⅝
..	..	7	3	2	6
12	0	5	0	9	9½
..	..	5	3	8	8⅛
..	..	5	6	7	8⅛
..	..	5	9	6	8¼
..	..	6	0	6	0
..	..	6	3	5	3½
..	..	6	6	4	7⅛
..	..	6	9	4	1
..	..	7	0	3	6⅛
..	..	7	3	3	1⅜
..	..	7	6	2	8½
..	..	7	9	2	4
..	..	8	0	2	0

The *beam* of an engine during its motion describes a curve more or less, varying with the radius of the beam and length of the stroke, the deviation from the straight line being the versed sine of the arc described by the beam; and in erecting an engine, the centre of the cylinder must be placed directly in a line, or exactly under half the versed sine, so that the angles of the links in the motion may be rendered equal. The versed sine is always equal to the difference of the base and hypotenuse of a triangle, whose hypotenuse equal the radius of the beam and perpendicular half the length of stroke; hence, Add together the radius of the beam and half the length of stroke, multiply the sum by their difference, extract the square root of the product, and the radius of the beam minus the square root equal the versed sine.

EXAMPLE.—Let the radius of a beam equal $7\frac{1}{2}$ feet, or 90 inches, length of stroke 5 feet, or 60 inches; required the versed sine.

$90 + 30 = 120$ and $90 - 30 = 60$, then

$\sqrt{120 \times 60} = 84.87$ and $90 - 84.87 = 5.13$ inches, or versed sine.

Or, as an approximate,—Divide the square of half the length of the stroke in inches by twice the radius of the beam, also in inches, and the quotient is the versed sine; thus,

$$\frac{30^2}{90 \times 2} = \frac{900}{180} = 5 \text{ inches.}$$

Table of versed sines for beams and strokes of various lengths.

Radius of beam in Ft.	& In.	Length of stroke in Ft.	& In.	Versed sine in inches.
4	0	2	0	1½
..	..	2	3	2
..	..	2	6	2⅜
..	..	2	9	2⅞
..	..	3	0	3⅜
4	6	2	0	1⅜
..	..	2	3	1¾
..	..	2	6	2⅛
..	..	2	9	2⅝
..	..	3	0	3
..	..	3	6	4¼
5	0	2	6	1⅞
..	..	2	9	2¼
..	..	3	0	2¾
..	..	3	6	3⅝
..	..	3	9	4¼
5	6	2	6	1¾
..	..	2	9	2
..	..	3	0	2½
..	..	3	6	3⅜
..	..	4	0	4⅜
6	0	3	0	2¼
..	..	3	6	3
..	..	4	0	4
..	..	4	6	5
6	6	3	0	2⅛
..	..	3	6	2⅞
..	..	4	0	3⅝
..	..	4	6	4⅝
..	..	5	0	5¾
7	0	3	6	2⅝
..	..	4	0	3½
7	0	4	6	4⅜
..	..	5	0	5⅜
7	6	3	6	2⅛
..	..	4	0	3¼
..	..	4	6	4⅛
..	..	5	0	5
..	..	5	6	6⅛
8	0	4	0	3
..	..	4	6	3¾
..	..	5	0	4¾
..	..	5	6	5⅝
8	6	4	0	2⅞
..	..	4	6	3⅝
..	..	5	0	4½
..	..	5	6	5⅜
9	0	4	6	3⅜
..	..	5	0	4¼
..	..	5	6	5⅛
..	..	6	0	6
9	6	5	0	4
..	..	5	6	4¾
..	..	6	0	5⅝
10	0	5	0	3¾
..	..	5	6	4½
..	..	6	0	5½
11	0	5	6	4⅛
..	..	6	0	5
..	..	6	6	5¾
12	0	6	0	4½
..	..	6	6	5⅛
..	..	7	0	6⅛

THE FLY WHEEL.

Fly wheels, *in general*, are for the purpose of equalizing motion; but in a steam-engine the fly wheel is also the means by which uniform circular motion is obtained from alternate rectilinear motion; and, to produce a proper effect, require a certain momentum, or a certain weight in motion, at a certain velocity; hence the following rule, deduced from practice, gives the weight of the wheel in all ordinary cases:—

RULE.—Divide 1400 times the number of horses' power the engine is equal to by the diameter of the wheel in feet, multiplied by the number of revolutions per minute, and the quotient is the weight of the ring or rim of the wheel, in cwts.

EXAMPLE.—Required the necessary weight for the ring or rim of a fly wheel for a thirty horse engine, making 18 revolutions per minute, the wheel to be 25 feet diameter.

$$\frac{1400 \times 30}{25 \times 18} = 93.3 \text{ cwts.}$$

To determine the dimensions of the ring, suitable to a given weight in cast iron.

RULE 1.—Make the breadth in inches about equal to the square root of the weight in cwts.

2.—Add together the inside and outside diameters of the ring in inches, multiply the sum by their difference, and by .2065 for a divisor, by which divide the required weight in lbs., and the quotient is the thickness of the ring in inches. Thus,—Suppose the weight and dia-

meter of the wheel, as above; required the breadth and thickness.

$\sqrt{93.3} = 9.7$ inches, breadth of ring, or say $9\frac{1}{2}$,

Then, $25 \times 12 = 300$ inches, and
$93.3 \times 112 = 10449.6$ lbs.
$300 - 19 = 281$, or inside diameter,
$300 + 281 \times 19 \times .2065 = 2279.6$,

And, $\dfrac{10449.6}{2279.6} = 4.5$ inches in thickness.

Or, if the ring be required of a cylindrical form, multiply the square root of the cross sectional area by 1.12837, and the product is the diameter. Hence,

$$\sqrt{9.5 \times 4.5} \times 1.12837 = 7.38 \text{ inches diameter.}$$

When a fly wheel of a known weight, at a given velocity, is required, to find the weight required at any other velocity,—or, the velocity required at any given weight.

Rule.—Multiply the weight required by its given velocity, and divide by the proposed velocity, the quotient is the weight required. Or, divide by the weight and the quotient equal the velocity.

Example 1.—Suppose the required weight of a fly wheel for an engine be 65 cwt., at 20 revolutions per minute, what weight will it require to be when the velocity is increased to 30 revolutions per minute?

$$\frac{65 \times 20}{30} = 43.3 \text{ cwt. for the weight of the ring.}$$

2.—Let the weight of a fly wheel be 43.3 cwt., with a velocity of 20 revolutions per minute, required the increased velocity, so that the momentum may equal 65 cwt.

$$\frac{65 \times 20}{43.3} = 30 \text{ revolutions per minute.}$$

FLY WHEEL SHAFT, PADDLE SHAFTS, &c.

In speaking of shafts, it is the journals, or bearings of the shaft that must be understood; and according to the different materials of which they are formed, or the different purposes to which they are applied, so do they require to be of different dimensions; hence the following proportions are the result of our present practice:

Multipliers
- 450 for cast-iron shafts in land or stationary engines,
- 356 for wrought-iron paddle shafts for seagoing vessels,
- 194 for wrought-iron paddle shafts for small river packets, &c.

General Rule.—Multiply the number of horses' power by the multiplier opposite the purpose to which it is to be employed, divide the product by the number of revolutions per minute, and the cube root of the quotient is the shaft's diameter in inches.

Example.—Required the diameter of a wrought-iron paddle shaft for an engine of 40 horse power, making 25 revolutions per minute.

$$\sqrt[3]{\frac{356 \times 40}{25}} = 8.28 \text{ inches diameter.}$$

Locomotive crank axles for 12 inch cylinders have bearings about 5 inches diameter, and fore axles $4\frac{1}{4}$ in. diameter; hence, $5^3 \div 12^2 = .86$, and $4.25^3 \div 12^2 = .53$, by which the diameters of other axles may be found in the same proportion, when the diameter of the cylinders are given.

Rule.—Multiply the square of the cylinder's dia-

meter in inches by .86 for crank axles, or .53 for fore axles, and the cube root of the product equal the diameter in inches.

EXAMPLE.—Let the diameter of the cylinders of a locomotive engine equal 14 inches; required the diameters of the bearings for the crank and fore axles.

$\sqrt[3]{14^2 \times .86} =$ 5.52 inches, diameter of the crank axle,

And $\sqrt[3]{14^2 \times .53} =$ 4.69 inches, diameter of the fore axle.

THE GOVERNOR, OR REGULATOR,

Is a necessary appendage attached to land or stationary engines, for the purpose of regulating the quantity of steam according to the quantity of work, and thereby causing a uniformity of motion, which otherwise would not be the case.

Governors are variously constructed, to suit the different situations in which they require to be placed, but their general principle is the same, and consists of a double pendulum attached to, and made to revolve round on a spindle by the power of the engine; consequently, the pendulums ought to be of a certain length to correspond to a given velocity,—or, the velocity made to correspond with pendulums of a given length. Hence, according to the nature of a pendulum, the square root of its length multiplied by the number of vibrations in a given time equal a number by which the length and number of vibrations of other pendulums are regulated; thus, a pendulum that will vibrate seconds, or 60 in the latitude of London, is 39.1393 inches long; and $\sqrt{39.1393} \times 60 = 375.36$, or, for the purposes of a governor, 375; and hence,

RULE 1.—Divide 375 by the square root of the pendulum's length, and the quotient equal the vibrations per minute, or half the quotient equal the number of revolutions in the same time.

2.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient equal the pendulum's length in inches.

EXAMPLE 1.—Required the number of revolutions per minute for a governor with pendulums 30 inches in length.

$$\frac{375}{\sqrt{30}} = 68.5 \div 2 = 34.25 \text{ revolutions per minute.}$$

Ex. 2.—Required the length of pendulums for a governor to make 47 revolutions per minute.

$$\frac{375}{47 \times 2} = 3.99^2 = 15.92 \text{ inches in length.}$$

The motion of a governor is generally derived from the fly wheel shaft of an engine, and communicated by means of pulleys, wheels, &c.; therefore, *to find the diameter of a pulley, or number of teeth in a wheel to produce any required velocity*, observe the following

RULE.—Multiply the diameter of the pulley, or number of teeth in the wheel on the governor spindle, by the velocity of the governor, or number of revolutions per minute, and divide by the velocity or number of revolutions of the engine in the same time; the quotient is the pulley's diameter, or number of teeth in the wheel on the fly wheel shaft. Or, Multiply the velocity of the engine per minute by the diameter of the pulley, or number of teeth in the wheel on the fly wheel shaft, and divide by the required velocity of the governor; the quotient is the pulley's diameter, or number of teeth in the wheel on the governor spindle.

EXAMPLE 1.—Required the diameter of a pulley for

the spindle of a governor, so that it may perform 36 revolutions per minute; velocity of the engine 22, and the pulley on the fly wheel shaft 18 inches diameter.

$$\frac{22 \times 18}{36} = 11 \text{ inches diameter.}$$

Ex. 2.—Suppose an engine and governor situated as follow:—

Velocity of the engine 34 revolutions per minute,
Velocity of the governor 52 revolutions per minute,
Diameter of pulley on fly wheel shaft 16 inches,
Diameter of pulley on intermediate shaft 12 inches,
Wheel on governor spindle 40 teeth;

Required the number of teeth in the wheel on the intermediate shaft.

$$\frac{52 \times 40 \times 12}{34 \times 16} = 46 \text{ teeth.}$$

Ex. 3.—Again, suppose the engine and governor situated as above; required the diameter of the pulley on the intermediate spindle.

$$\frac{34 \times 16 \times 46}{52 \times 40} = 12 \text{ inches diameter.}$$

NOTE.—The weight of the balls in lbs. ought to be about $1\frac{1}{4}$ times the length of the pendulums in inches, and the levers to the throttle valve ought to be so adjusted that the greatest angle of the pendulums with the spindle may not exceed about 45 degrees.

A SUMMARY OF MISCELLANEOUS REMARKS, TABLES, AND PROPORTIONS.

Proportionate power for steam-packets.—The power of an engine or engines for a steam-packet on a river, lake, &c. ought to be equal to 1 horse for every 2 tons, builders' measurement. Coasting packets, having an average run of 250 to 300 miles, 1 horse power to every $2\frac{1}{2}$ tons. And sea-going packets, whose average runs are from 700 to 1000 miles, 1 horse power to every $3\frac{1}{2}$ tons.

Power for steam-packets with increased velocity.—The power requisite to propel a packet or vessel of any description, at a given increase of velocity, is as the cube of the one velocity is to the cube of the other. Hence, suppose a power of 50 horses is required to propel a vessel at the rate of 8 miles per hour, what must be the power so as to propel the same at the rate of 10 miles per hour?

$$\frac{10^3 \times 50}{8^3} = \frac{50000}{512} = 97.6 \text{ horses' power.}$$

Paddle wheels.—The proportionate diameter of pad-wheels is, for river packets, &c. about $7\frac{1}{2}$ times the length of the crank. For coasting and sea-going vessels 8 to $8\frac{1}{2}$ times the length of the crank; and in either case the surface of the paddle boards calculated according to the rule given at page 38. Distance between each board at the extreme diameter of the wheel about $3\frac{1}{2}$ feet.

Paddle shafts.—A common rule for the diameters of the bearings of wrought iron paddle shafts is,—

For river packets—inside bearings $\frac{1}{6}$, outside bearings, $\frac{1}{8}$.
And other packets „ $\frac{1}{5}$ „ $\frac{1}{7}$
of the cylinder's diameter.

Piston rods.—Diameter of piston rods for land engines with long strokes, and marine engines for sea-going vessels, $\frac{1}{10}$th of the cylinder's diameter. For land engines with short strokes, and river packet engines, $\frac{1}{12}$th. Locomotive engines, $\frac{1}{7}$th.

Air pump rods.—Diameter of air pump rods, $\frac{1}{10}$th of the pump's diameter; if copper, $\frac{1}{8}$th.

Length of stroke.—Proportionate length of stroke for condensing engines, twice the cylinder's diameter; non-condensing, three times.

Injection cocks.—Area of injection cock about .4 of an inch to each horse power. Or, make the diameter of the cock $\frac{1}{15}$th of the cylinder's diameter.

Chimneys.—Diameter of steam-packet and locomotive chimneys equal the diameter of the cylinder. In vessels with only one engine, $\frac{2}{3}$ds the cylinder's diameter.

Fuel.—In the consumption of fuel in steam-engines much depends upon the quality of the fuel, as regards the quantity expended, and effect produced. Coal varies from 8 to 13 lbs. in evaporating one cubic foot of water, but a greater body of fire will evaporate a greater quantity of water with a less proportion of fuel; hence, *large* engines require less fuel in proportion to their power than *small* ones.

Proportionate consumption of fuel.—It is ascertained from practice that steam at 3 lbs. per square inch, and produced from water of an average quality, requires to be maintained with about $13\frac{1}{2}$ lbs. of good coal per hour for each horse power, when the lap or cover of the valve is $\frac{1}{4}$th the width of the opening to the cylinder.

Steam at $4\frac{1}{2}$ lbs. per square inch requires 11 lbs. of coal, when the cover of the valve is $\frac{1}{3}$d; and, Steam at 6lbs. requires 8 lbs. of coal, when the cover of the valve is $\frac{1}{2}$ the width of the opening to the cylinder.

Comparative comsumption of fuel.—To convert 1 cubic foot of water, of an average quality, at 52° Ft., to steam at 220°, requires

Of Newcastle or caking coal, about	8.4	lbs. avd.
Splint coal	8.4	,,
Staffordshire cherry coal	11.2	,,
Pine wood	19.2	,,
Charcoal	10.6	,,
Coke	7.7	,,

Boiling points of water.—Boiling point of pure water under common atmospheric pressure ......212° Ft.

Sea water........................				213.2
Water holding in solution		$\frac{2}{33}$	parts salt,	214.4
,,	,,	$\frac{6}{33}$	,,	219
Saturated water	,,	$\frac{12}{33}$	,,	226

The following is a summary of experiments on the Grand Junction Railway, for the purpose of ascertaining the quantity of coke consumed to the quantity of load transported.

Names of engines.	Date of experiment, 1838.	LOAD.			RATE OF TRAVELLING.				COKE CONSUMED.				WATER EVAPORATED.		
		Carriage, &c.	Engine and tender.	Gross load.	Total distance run.	Time.		Mean rate.	Total quantity in	Per mile.	Per ton per mile.		During the trip.	Cubic feet.	Lbs. of coke.
											Goods.	Gross load.			
		Tons.	Tons.	Tons.	Miles.	Hr.	Mt.	Miles ℔ hour	Lbs.	Lbs.	Lbs.	Lbs.	Imperial gallons.	Per hour.	Per cubic ft
Phalaris ...	May 30, ... 31, June 1, July 5	39.2	20	59.2	778	33	46	23.05	28812	37.03	.95	.62	17230	81.9	10.43
Prometheus	June 5, ... 6, ... 7, ... 8	36.7	20	56.7	778	34	33	22.53	26715	34.3	.93	.60	17610	81.7	9.39
Prometheus	June 11, ... 12, ... 13	32.8	20	52.8	583.5	26	6	22.38	24493	41.9	1.28	.79	12740	78.2	11.97
Phalaris ...	June 14, ... 15, ... 16	42.6	20	62.6	583.5	26	28	22.08	22488	38.5	.90	.61	11450	67.6	12.24
Prometheus	June 22, ... 23, ... 25, ... 26	41.1	20	61.1	778	36	5	21.49	36686	47.1	1.14	.77	19050	84.6	11.98
Phalaris ...	July 2, ... 3, ... 4	34.46	20	54.46	583.5	24	42	23.62	20652	35.4	1.03	.65	12360	80.3	10.49

[*Railway Times.*]

Table of experiments on the London and Birmingham Railway.

Description of the engines.	LOAD.			VELOCITY.			COKE CONSUMED.			WATER EVAPORATED.		
	Carriages, Passengers, &c.	Engine and tender.	Gross load in	Rate at full speed in miles per hour.	Pressure of steam per square inch.	Mean rate of speed in miles per hour.	During the trip.	Per ton per mile.	Per mile. Gross	During the trip.	Cubic feet per hour.	Pounds of coke ℔ cub. foot.
	Tons.	Tons.	Tons.	Miles.	Lbs.	Miles.	Lbs.	Goods.	Load.	Galls.	Feet.	Lbs.
12 inch cylinders, and 5 feet wheels...	32.65	17.5	50.15	32.88	53	30.51	434	.891b	.471b	300	83.81	8.85
	53.45	17.5	70.95	32.4	53	28.53	601	.59	.4	506	105.9	7.59
	64.36	17.25	81.61	25.53	53	21.85	391	.504	.35	317	70.66	7.62
12 inch cylinders, and 5 feet wheels...	34.45	16.32	50.77	32.41	53.5	31.29	606	1.01	.55	420	91.	8.9
	53.91	15.85	69.76	32.04	53.5	29.82	590	.58	.41	405	94.42	8.13
	67.2	16.33	83.53	23.81	53.5	19.42	1220	.36	.29	935	56.81	8.11

Experiments on the Liverpool and Manchester Railway.—Similar experiments were also made upon the Liverpool and Manchester Railway, by which it was ascertained that an engine having 12 inch cylinders, 16 inch stroke, and 5 feet wheels ; surface exposed to the action of the fire, or radiating caloric, 57 square feet, and tube surface, or communicative caloric, 218 square feet, average evaporating power per hour 45 cubic feet, with an average effective pressure of 54lbs. per square inch, and drawing a load of 190 tons; consumed, of good coke, during the trip of $29\frac{1}{2}$ miles, 1596 lbs., or 28 lbs. per ton per mile on a level; And also the same engine, running the same distance with 25 tons, under as favourable circumstances, consumed 720 lbs., or .82 lbs. per ton per mile. Hence it appears, that the nearer the load approaches to the calculated power of the engine, the less the quantity of fuel expended in proportion to the weight of the load. Again, the first trip was performed in 3 hours and 2 minutes, and the second in 1 hour and 26 minutes, therefore, about *eight* times the load required only about *twice* the quantity of coke, and the journey performed in little more than *twice* the time.

Distribution of weight in locomotive engines.—The weight of a locomotive engine ought to be so distributed that about $\frac{2}{3}$ds of the whole weight may rest upon the crank axle. When so proportioned with coupled wheels, and the rails dry and clean, the force of adhesion equals at least 45 times the weight upon the crank axle. Thus, suppose an engine of 8 tons,

$$\frac{8 \times 2}{3} = 5.33 \text{ tons upon the crank axle ;}$$

And $5.33 \times 45 = 239.85$ tons, or the force of adhesion upon the rails.

Table of railway gradients, or inclined planes.

1 ft. per mile	= 1 in 5280	or .15	of an inch per chain.
2	= 1 .. 2640	.. .30	
3	= 1 .. 1760	.. .45	
4	= 1 .. 1320	.. .60	
5	= 1 .. 1056	.. .75	
6	= 1 .. 880	.. .90	
7	= 1 .. 754.2	.. 1.05	
8	= 1 .. 660.0	.. 1.20	
9	= 1 .. 586.6	.. 1.35	
10	= 1 .. 528.0	.. 1.50	
11	= 1 .. 480.0	.. 1.65	
12	= 1 .. 440.0	.. 1.80	
13	= 1 .. 406.1	.. 1.95	
14	= 1 .. 377.1	.. 2.10	
15	= 1 .. 352.0	.. 2.25	
16	= 1 .. 330.0	.. 2.40	
17	= 1 .. 310.6	.. 2.55	
18	= 1 .. 293.3	.. 2.70	
19	= 1 .. 277.9	.. 2.85	
20	= 1 .. 264.0	.. 3.00	
21	= 1 .. 251.4	.. 3.15	
22	= 1 .. 240.0	.. 3.30	
23	= 1 .. 229.5	.. 3.45	
24	= 1 .. 220.0	.. 3.60	
25	= 1 .. 211.2	.. 3.75	
26	= 1 .. 203.1	.. 3.90	
27	= 1 .. 195.5	.. 4.05	
28	= 1 .. 188.6	.. 4.20	
29	= 1 .. 182.1	.. 4.35	
30	= 1 .. 176.0	.. 4.50	
31	= 1 .. 170.3	.. 4.65	
32	= 1 .. 165.0	.. 4.80	
33	= 1 .. 169.0	.. 4.95	
34	= 1 .. 155.3	.. 5.10	
35	= 1 .. 150.8	.. 5.25	
36	= 1 .. 146.6	.. 5.40	
37	= 1 .. 142.7	.. 5.55	
38	= 1 .. 138.9	.. 5.70	
39	= 1 .. 135.4	.. 6.15	
40	= 1 .. 132.0	.. 6.00	
41	= 1 .. 128.8	.. 6.85	
42	= 1 .. 125.7	.. 6.30	
43	= 1 .. 122.8	.. 6.45	
44	= 1 .. 120.0	.. 6.60	
45	= 1 .. 117.3	.. 6.75	
46	= 1 .. 114.8	.. 6.90	
47	= 1 .. 112.3	.. 7.05	
48	= 1 .. 110.0	.. 7.20	
49	= 1 .. 107.7	.. 7.35	
50	= 1 .. 105.6	.. 7.50	
51	= 1 .. 103.5	.. 7.65	
52	= 1 .. 101.5	.. 7.80	
53	= 1 .. 99.6	.. 7.95	
54	= 1 .. 97.8	.. 8.10	
55	= 1 .. 96.0	.. 8.25	
56	= 1 .. 94.3	.. 8.40	
57	= 1 .. 92.6	.. 8.55	
58	= 1 .. 91.0	.. 8.70	
59	= 1 .. 89.5	.. 8.85	
60	= 1 .. 88.0	.. 9.00	

NOTE.—The following exhibits in some measure the effect or power of an engine in ascending or descending inclined planes :—

Suppose the power 1 in ascending a plane of 10 feet per mile, the following is the result or effect;—the force of traction taken at 10 lbs. per ton.

GRADIENTS.	COMPARATIVE EFFECTIVE POWER. Ascending.	Descending.
Level	1.56	1.56
4 feet per mile	1.29	1.95
10	1.00	2.97
16	.80	5.56
20	.69	7.26

Curves on railways.—The following table contains the rise or elevation that must be given to the outer rail of a curve upon a railway, for waggons with wheels of 3 feet diameter,—width between the rails 4 feet $8\frac{1}{2}$ inches,—play of the wheels between the rails 1 inch,—and the conicleness or inclination of the tire equal $\frac{1}{7}$ of the breadth from the flange.

Radius of the curve in feet.	Elevation in inches, the average velocity per hour being 10 miles.	20 miles.	30 miles.
250	1.14 in.	5.60 in.	12.99 in.
500	.57	2.83	6.56
1000	.29	1.43	3.30
2000	.15	.71	1.65
3000	.10	.47	1.10
4000	.07	.36	.83
5000	.06	.28	.66

The elevation for any other arrangement may be ascertained by the following practical formula:—

Let D = the diameter of the wheels in feet,
r = the radius of the curve in feet,
e = half the width of the way in feet,
V = the average velocity in feet per second; thus, 20 miles per hour = 29.3 feet per second,
g = the accelerating force of gravitation, or 32 feet per second,
a = 7, or the inclination of the tire,
And y = the rise, or elevation of the outward rail over the inward rail, expressed also in feet.

$$\text{Then } y = \frac{e V^2}{g r}\left\{2 - \frac{a D}{2(r+e)}\right\} - \frac{e D}{r+e}$$

To find the radius of any curve, or portion of a circle.

RULE.—Take any length of a chord or straight line in the curve, and, to the square of half its length, add the square of the versed sine, divide the sum by twice the versed sine, and the quotient is the radius. Thus,

Suppose the length of the chord in a curve equal 1 chain, or 66 feet, and versed sine $1\frac{1}{2}$ feet; required the radius.

$$\frac{33^2 + 1.5^2}{1.5 \times 2} = 363.75 \text{ feet.}$$

Leveling.—In leveling railways, canals, &c., the level obtained by means of an instrument, or *level*, is only what is called *apparent level*, or a tangent to the earth's circumference. The earth being a sphere, or nearly so, the *true level* is a curve line equally distant from its centre; hence, to obtain the difference between true and apparent level,

Divide the square of any distance on the earth's circumference by the earth's diameter, and the quotient is the difference, in terms of the same denomination.

For example,—The earth's mean diameter equal 7912 miles, or 501,304,320 inches; consequently, the difference of true and apparent level at the distance of 1 mile, or 63,360 inches, will be

$$\frac{63360^2}{501304320} = 7.962, \text{ or very nearly eight inches.}$$

But although this be the exact difference between true and apparent level on the earth's circumference, in leveling to any distance, the point of sight is depressed about one-seventh of the true difference, by the curvature—refraction of the rays of light; consequently, the difference will be $\frac{7.962}{7} = 1.137$ and $7.962 - 1.137 = 6.825$, or what may be termed the *practical* difference between true and apparent level.

A Table of difference between true and apparent level.

Distance in yards.	True difference of level in inches.	Practical difference in inches.	Distance in miles.	True difference in feet & inches.	
100	.026	.023	¼	0	0½
200	.103	.088	½	0	2
300	.231	.198	¾	0	4½
400	.411	.353	1	0	8
500	.643	.551	2	2	8
600	.925	.793	3	6	0
700	1.260	1.08	4	10	7
800	1.645	1.41	5	16	7
900	2.081	1.78	6	23	11
1000	2.570	2.20	7	32	6
1100	3.110	2.66	8	42	6
1200	3.701	3.17	9	53	9
1300	4.344	3.72	10	66	4
1400	5.038	4.32	11	80	3
1500	5.784	4.96	12	95	7
1600	6.580	5.64	13	112	2
1700	7.425	6.76	14	130	1

A Table of the force and velocity of the wind.

VELOCITY		Force in lbs. avoirdupois per square foot.
In miles per hour.	In feet per second.	
1	1.47	.005
2	2.93	.020
3	4.40	.044
4	5.87	.079
5	7.33	.123
10	14.67	.492
15	22.00	1.107
20	29.34	1.968
25	36.67	3.075
30	44.01	4.429
35	51.34	6.027
40	58.68	7.873
45	66.01	9.963
50	73.35	12.300
60	88.02	17.715
80	117.36	31.490
100	146.70	49.200

Divisions of different Thermometers.—Degrees of heat vary in different countries, according to the different thermometers made us of. Thus, in Britain, *Fahrenheit's* thermometer is the standard of estimation,—in France, *Celsius*, or *Centigrade*,—in Germany, *Reaumur*—and in Russia, that of *De Lisle;* the boiling and freezing points of which differ as follows:—

	FAHRENHEIT.		CENTIG.		REAUM.		DE LISLE.
Boiling point ..	212°		100°		80°		0°
Freezing point..	32		0		0		150
Thus, ..	90	=	5	=	4	=	7½

A Table of corresponding degrees of temperature of Fahrenheit, Reaumur, and the Centigrade Scale.

Faht.	Reaum.	Centig.	Faht.	Reaum.	Centig.
214°	80.9°	101.1°	240°	92.4	115.5
216	81.8	102.2	242	93.3	116.6
218	82.7	103.3	244	94.2	117.7
220	83.6	104.4	246	95.1	118.8
222	84.4	105.6	248	96.0	120.0
224	85.3	106.7	250	96.9	121.1
226	86.2	107.8	260	101.3	126.6
228	87.1	108.9	270	105.8	132.2
230	88.0	110.0	280	110.2	137.8
232	88.9	111.1	290	114.7	143.3
234	89.8	112.2	300	119.1	148.9
236	90.7	113.3	320	128.0	160.0
238	91.6	114.4	350	141.3	176.7

NOTE.

Water at 32°	Faht.	0°	Reaum.	1°	Cent.	= in volume 1.000109.
.... 42	......	5.5	....	4.4	......	= .... 1.
..........212	......	80	....	100	......	= .... 1.04382.
Water at 212	saturated with salt					= .... 1.05198.
Air...... 32	Faht.	0	Reaum.	1	Cent.	= .... 1.
..........212	......	80	....	100	......	= .... 1.3750.
..........392	......	160	....	200	......	= .... 1.7389.
..........572	......	240	....	300	......	= .... 2.0976.

Properties of various metals.

Names.	Colour.	Specific gravity.	Weight of a lineal foot 1 inch square.	Weight of a lineal foot 1 inch diam.	Melting point, Faht.	Scale of ductility.	Scale of malleability.	Ratio of hardness.	Cohesive power of an inch square bar.	Bears in lbs. on a square inch without any alteration	Power of conducting heat.	Scale as conductors of electricity.
			Lbs.	Lbs.					Lbs.	Lbs.		
Gold	Pure yellow......	19.35	8.40	6.59	5237°	1	1	1.8	30888	......	10.0	3
Silver	White	10.51	4.54	3.56	4717	2	2	2.4	38257	......	9.7	2
Iron, cast......	Blue gray.........	7.27	3.12	2.45	17977	4	8	...	18656	15300	.....	...
Iron, wrought,	....	7.63	3.33	2.61	......	3	5	4.7	93964	17800	3.7	4
Copper	Red	8.90	3.84	3.02	4587	5	3	2.8	61228	10000	8.9	1
Lead	Blue	11.35	4.93	3.87	594	8	6	1.0	2581	1500	1.8	6
Tin	White	7.29	3.16	2.48	442	7	4	1.2	5322	2880	3.0	5
Zinc	Bluish white......	7.00	3.05	2.39	700	6	7	1.6	16600	5700	3.6	7
Bismuth	Yellowish white	9.88	4.26	3.34	476	...	...	2.0	3008	......	.....	...
Antimony......	Bluish white.....	6.70	......	......	932	...	...	1.4	1006	......	.....	...

NOTE.—Water is *decomposed* by iron, tin, or zinc, at a red heat, but any of the other metals will not decompose water at any temperature.

Table of the friction of metals on metals.

Friction or resistance of		without unguents, equal about		of the whole weight or pressure on the surface.
	Brass on wrought iron		1/7	
	Cast iron on cast iron		1/6	
	Soft steel on wrought iron ...		1/5	
	Brass on steel....................		1/6	
	Brass on brass....................		1/5	
	Cast iron on wrought iron ...		1/6	
	Cast iron on soft steel		1/6	
	Tin on tin		1/3	
	Soft steel on soft steel		1/6	
	Cast iron on hard brass		1/6	
	Wrought iron on wrought iron		1/6	
	Brass on cast iron		1/6	
	Tin on wrought iron...........		1/5	
	Tin on cast iron.................		1/5	

NOTE.—From 1½ cwt. to upwards of 6 cwt. per square inch the resistance increases in a very considerable ratio, being the greatest with steel on cast iron, and the least with brass on wrought iron.

Properties of the circle, sphere, &c.

The diameter of a circle being		1.
The Circumference.....................	=	3.1416
„ Area	=	.7854
„ Side of equal square	=	.8862
„ Radius being 1, the area	=	3.1416
„ Circumference being 1, the side of equal square	=	.2821

The diameter of a sphere being		1.
The superficies	=	3.1416
„ Solidity	=	.5236
„ Side of an equal cube..............	=	.806
„ Length of an equal cylinder of the same diameter	=	.6667

Any circle twice the diameter of another contains twice the circumference of the other, and four times the area. Hence, the circumferences of circles are as their diameters, and their areas as the squares of their diameters.

Any sphere or globe, twice the diameter of another, contains four times the superficies of the other, and eight times the solid content. Hence, the superficies of spheres are as the squares, and the solidity as the cubes of their diameters.

Various French measures of frequent reference.

A point is equal to......	.0148025	English inches.	
A line	.088815	„	
A millemetre	.039371	„	
A centimetre	.39371	„	
An inch or pouce	1.06578	„	
A decimetre.........	3.9371	„	
A foot	12.78933	„	
A metre	39.371	„	or 3.2809 English ft.
A toise, or fathom	6.394	English feet.	
A league...............	14591.1	„	or 4863.7 English yards.
A square inch	1.13582	English square inches.	
A cubic inch	1.21063	„ cubic „	
A cubic metre	35.316	„ cubic feet.	

TABLES

OF

THE WEIGHT OF METALS;

SQUARE AND CUBE ROOTS OF NUMBERS;

CIRCUMFERENCES AND AREAS OF CIRCLES;

SUPERFICIES AND SOLIDITIES OF SPHERES

&c. &c. &c.

TABLE I,

Containing the weight of square bar iron, from 1 *to* 10 *feet in length, and from* ¼ *of an inch to* 6 *inches square.*

Inches square.	LENGTH OF THE BARS IN FEET.									
	1 foot.	2 feet.	3 feet.	4 feet.	5 feet.	6 feet.	7 feet.	8 feet.	9 feet.	10 feet.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
¼	0.2	0.4	0.6	0.8	1.1	1.3	1.5	1.7	1.9	2.1
⅜	0.5	1.0	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.8
½	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.5
⅝	1.3	2.6	4.0	5.3	6.6	7.9	9.2	10.6	11.9	13.2
¾	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1	19.0
⅞	2.6	5.2	7.8	10.4	12.9	15.5	18.1	20.7	23.3	25.9
1 *in.*	3.4	6.8	10.1	13.5	16.9	20.3	23.7	27.0	30.4	33.8
1⅛	4.3	8.6	12.8	17.1	21.4	25.7	29.9	34.2	38.5	42.8
1¼	5.3	10.6	15.8	21.1	26.4	31.7	37.0	42.2	47.5	52.8
1⅜	6.4	12.8	19.2	25.6	32.0	38.3	44.7	51.1	57.5	63.9
1½	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4	76.0
1⅝	8.9	17.9	26.8	35.7	44.6	53.6	62.5	71.4	80.3	89.3
1¾	10.4	20.7	31.1	41.4	51.8	62.1	72.5	82.8	93.2	103.5
1⅞	11.9	23.8	35.6	47.5	59.4	71.3	83.2	95.1	106.9	118.8
2 *in.*	13.5	27.0	40.6	54.1	67.6	81.1	94.6	108.2	121.7	135.2
2⅛	15.3	30.5	45.8	61.1	76.3	91.6	106.8	122.1	137.4	152.6
2¼	17.1	34.2	51.3	68.4	85.6	102.7	119.8	136.9	154.0	171.1
2⅜	19.1	38.1	57.2	76.3	95.3	114.4	133.5	152.5	171.6	190.7
2½	21.1	42.2	63.4	84.5	105.6	126.7	147.8	169.0	190.1	211.2
2⅝	23.3	46.6	69.9	93.2	116.5	139.8	163.0	186.3	209.6	232.9
2¾	25.6	51.1	76.7	102.2	127.8	153.4	178.9	204.5	230.0	255.6
2⅞	27.9	55.9	83.8	111.8	139.7	167.6	195.7	223.5	251.5	279.4
3 *in.*	30.4	60.8	91.2	121.7	152.1	182.5	212.9	243.3	273.7	304.2
3⅛	33.0	66.0	99.0	132.0	165.1	198.1	231.1	264.1	297.1	330.1
3¼	35.7	71.4	107.1	142.8	178.5	214.2	249.9	285.6	321.3	357.0
3⅜	38.5	77.0	115.5	154.0	192.5	231.0	269.5	308.0	346.5	385.0
3½	41.4	82.8	124.2	165.6	207.0	248.4	289.8	331.3	372.7	414.1
3⅝	44.4	88.8	133.3	177.7	222.1	266.5	310.9	355.3	399.8	444.2
3¾	47.5	95.1	142.6	190.1	237.7	285.2	332.7	380.3	427.8	475.3
3⅞	50.8	101.5	152.3	203.0	253.8	304.5	355.3	406.0	456.8	507.6
4 *in.*	54.1	108.2	162.3	216.3	270.4	324.5	378.6	432.7	486.8	540.8
4⅛	57.5	115.0	172.6	230.1	287.6	345.1	402.6	460.1	517.7	575.2
4¼	61.1	122.1	183.2	244.2	305.3	366.3	427.4	488.4	549.5	610.6
4⅜	64.7	129.4	194.1	258.8	323.5	388.2	452.9	517.6	582.3	647.0
4½	68.4	136.9	205.3	273.8	342.2	410.7	479.1	547.6	616.0	684.5
4⅝	72.3	144.6	216.9	289.2	361.5	433.8	506.1	578.4	650.7	723.1
4¾	76.3	152.5	228.8	305.1	381.3	457.6	533.8	610.1	686.4	762.6
4⅞	80.3	160.7	241.0	321.3	401.7	482.0	562.3	642.7	723.0	803.3
5 *in.*	84.5	169.0	253.4	337.9	422.4	506.9	591.4	675.8	760.3	844.8
5¼	93.2	186.3	279.5	372.7	465.8	559.0	652.2	745.3	838.5	931.7
5½	102.2	204.5	306.7	409.0	511.2	613.4	715.7	817.9	920.2	1022.4
5¾	111.8	223.5	335.3	447.0	558.8	670.5	782.3	894.0	1005.8	1117.6
6 *in.*	121.7	243.3	365.0	486.7	608.3	730.0	841.6	973.3	1009.5	1216.6

TABLE II,

Containing the weight of round bar iron, from 1 to 10 feet in length, and from 1/4 of an inch to 6 inches diameter.

Inches diam.	LENGTH OF THE BARS IN FEET.									
	1 foot.	2 feet.	3 feet.	4 feet.	5 feet.	6 feet.	7 feet.	8 feet.	9 feet.	10 feet.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1/4	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7
3/8	0.4	0.7	1.1	1.5	1.9	2.2	2.6	3.0	3.4	3.7
1/2	0.7	1.3	2.0	2.7	3.3	4.0	4.6	5.3	6.0	6.6
5/8	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	9.4	10.4
3/4	1.5	3.0	4.5	6.0	7.5	9.0	10.5	11.9	13.4	14.9
7/8	2.0	4.1	6.1	8.1	10.2	12.2	14.2	16.3	18.3	20.3
1 *in.*	2.7	5.3	8.0	10.6	13.3	15.9	18.6	21.2	23.9	26.5
1 1/8	3.4	6.7	10.1	13.4	16.8	20.2	23.5	26.9	30.2	33.6
1 1/4	4.2	8.3	12.5	16.7	20.9	25.0	29.2	33.4	37.5	41.7
1 3/8	5.0	10.0	15.1	20.1	25.1	30.1	35.1	40.2	45.2	50.2
1 1/2	6.0	11.9	17.9	23.9	29.9	35.8	41.8	47.8	53.7	59.7
1 5/8	7.0	14.0	21.0	28.0	35.1	42.1	49.1	56.1	63.1	70.1
1 3/4	8.1	16.3	24.4	32.5	40.6	48.8	56.9	65.0	73.2	81.3
1 7/8	9.3	18.7	28.0	37.3	46.7	56.0	65.3	74.7	84.0	93.3
2 *in.*	10.6	21.2	31.8	42.5	53.1	63.7	74.3	84.9	95.5	106.2
2 1/8	12.0	24.0	36.0	48.0	59.9	71.9	83.9	95.9	107.9	119.9
2 1/4	13.4	26.9	40.3	53.8	67.2	80.6	94.1	107.5	121.0	134.4
2 3/8	15.0	30.0	44.9	60.0	74.9	89.9	104.8	119.8	134.8	149.8
2 1/2	16.7	33.4	50.1	66.8	83.4	100.1	116.8	133.5	150.2	166.9
2 5/8	18.3	36.6	54.9	73.2	91.5	109.8	128.1	146.3	164.6	182.9
2 3/4	20.1	40.2	60.2	80.3	100.4	120.5	140.5	160.6	180.7	200.8
2 7/8	21.9	43.9	65.8	87.8	109.7	131.7	153.6	175.6	197.5	219.4
3 *in.*	23.9	47.8	71.7	95.6	119.4	143.3	167.2	191.1	215.0	238.9
3 1/8	25.9	51.9	77.8	103.7	129.6	155.6	181.5	207.4	233.3	259.3
3 1/4	28.0	56.1	84.1	112.2	140.2	168.2	196.3	224.3	253.4	280.4
3 3/8	30.2	60.5	90.7	121.0	151.2	181.4	211.7	241.9	272.2	302.4
3 1/2	32.5	65.0	97.5	130.0	162.6	195.1	227.6	260.1	292.6	325.1
3 5/8	34.9	69.8	104.7	139.5	174.4	209.3	244.2	279.1	314.0	348.9
3 3/4	37.3	74.7	112.0	149.3	186.7	224.0	261.3	298.7	336.0	373.3
3 7/8	39.9	79.7	119.6	159.5	199.3	239.2	279.0	318.9	358.8	398.6
4 *in.*	42.5	84.9	127.4	169.9	212.3	254.8	297.2	339.7	382.2	424.6
4 1/8	45.2	90.3	135.5	180.7	225.9	271.0	316.2	361.4	406.6	451.7
4 1/4	48.0	95.9	143.9	191.8	239.8	287.7	335.7	383.6	431.6	479.5
4 3/8	50.8	101.6	152.4	203.3	254.1	304.9	355.7	406.5	457.3	508.2
4 1/2	53.8	107.5	161.3	215.0	268.8	322.6	376.3	430.1	483.8	537.6
4 5/8	56.8	113.6	170.4	227.2	283.9	340.7	397.5	454.3	511.1	567.9
4 3/4	60.0	119.8	179.7	239.6	299.5	359.4	419.3	479.2	539.1	599.0
4 7/8	63.1	126.2	189.3	252.4	315.5	378.6	441.7	504.8	567.8	630.9
5 *in.*	66.8	133.5	200.3	267.0	333.8	400.5	467.3	534.0	600.8	667.5
5 1/4	73.2	146.3	219.5	292.7	365.9	439.0	512.2	585.4	658.5	731.7
5 1/2	80.3	160.6	240.9	321.2	401.5	481.8	562.1	642.4	722.7	803.0
5 3/4	87.8	175.6	263.3	351.1	438.9	526.7	614.4	702.2	790.0	877.8
6 *in.*	95.6	191.1	286.7	382.2	477.8	573.3	668.9	764.4	860.0	955.5

TABLE III,

Containing the weight of flat bar iron, 1 foot in length, of various breadths and thicknesses.

Breadth in inches.	THICKNESS IN PARTS OF AN INCH.									
	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1 inch.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1 *in.*	0.83	1.04	1.25	1.45	1.66	1.87	2.08	2.50	2.91	3.33
1⅛	0.93	1.17	1.40	1.64	1.87	2.00	2.34	2.81	3.28	3.75
1¼	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12	3.64	4.16
1⅜	1.14	1.43	1.71	2.00	2.29	2.57	2.86	3.43	4.01	4.58
1½	1.25	1.56	1.87	2.18	2.50	2.81	3.12	3.75	4.37	5.00
1⅝	1.35	1.69	2.03	2.36	2.70	3.04	3.38	4.06	4.73	5.41
1¾	1.45	1.82	2.18	2.55	2.91	3.28	3.64	4.37	5.10	5.83
1⅞	1.56	1.95	2.34	2.73	3.12	3.51	3.90	4.68	5.46	6.25
2 *in.*	1.66	2.08	2.50	2.91	3.33	3.75	4.16	5.00	5.83	6.66
2⅛	1.77	2.21	2.65	3.09	3.54	3.98	4.42	5.31	6.19	7.08
2¼	1.87	2.34	2.81	3.28	3.75	4.21	4.68	5.62	6.56	7.50
2⅜	1.97	2.47	2.96	3.46	3.95	4.45	4.94	5.93	6.92	7.91
2½	2.08	2.60	3.12	3.64	4.16	4.68	5.20	6.25	7.29	8.33
2⅝	2.18	2.73	3.28	3.82	4.37	4.92	5.46	6.56	7.65	8.75
2¾	2.29	2.86	3.43	4.01	4.58	5.15	5.72	6.87	8.02	9.16
2⅞	2.39	2.99	3.59	4.19	4.79	5.39	5.98	7.18	8.38	9.58
3 *in.*	2.50	3.12	3.75	4.37	5.00	5.62	6.25	7.50	8.75	10.00
3¼	2.70	3.38	4.06	4.73	5.41	6.09	6.77	8.12	9.47	10.83
3½	2.91	3.64	4.37	5.10	5.83	6.56	7.29	8.75	10.20	11.66
3¾	3.12	3.90	4.68	5.46	6.25	7.03	7.81	9.37	10.93	12.50
4 *in.*	3.33	4.16	5.00	5.83	6.66	7.50	8.33	10.00	11.66	13.33
4¼	3.54	4.42	5.31	6.19	7.08	7.96	8.85	10.62	12.39	14.16
4½	3.75	4.68	5.62	6.56	7.50	8.43	9.37	11.25	13.12	15.00
4¾	3.95	4.94	5.93	6.92	7.91	8.90	9.89	11.87	13.85	15.83
5 *in.*	4.17	5.20	6.25	7.29	8.33	9.37	10.41	12.50	14.58	16.66
5¼	4.37	5.46	6.56	7.65	8.75	9.84	10.93	13.12	15.31	17.50
5½	4.58	5.72	6.87	8.02	9.16	10.31	11.45	13.75	16.04	18.33
5¾	4.79	5.98	7.18	8.38	9.58	10.78	11.97	14.37	16.77	19.16
6 *in.*	5.00	6.26	7.50	8.75	10.00	11.25	12.50	15.00	17.50	20.00

NOTE.—The weight of wrought iron being 1.

The weight of cast iron	=	.96
Steel	=	1.03
Copper	=	1.17
Brass	=	1.1
Lead	=	1.48

TABLE IV.

Containing the weight of solid cylinders of cast iron, one foot in length, and from ¾ of an inch to 12 inches diameter.

Diameter in Inches.	*Weight in Lbs.*	*Diameter in Inches.*	*Weight in Lbs.*
¾	1.39	5 *in.*	61.96
⅞	1.88	5⅛	64.66
1 *in.*	2.47	5¼	68.31
1⅛	3.13	5⅜	71.00
1¼	3.87	5½	74.98
1⅜	4.68	5⅝	78.65
1½	5.57	5¾	81.95
1⅝	6.54	5⅞	85.81
1¾	7.59		
1⅞	8.71	6 *in.*	89.23
		6¼	96.82
2 *in.*	9.91	6½	104.72
2⅛	11.19	6¾	112.93
2¼	12.54		
2⅜	13.98	7 *in.*	121.45
2½	15.49	7¼	130.28
2⅝	17.08	7½	139.42
2¾	18.74	7¾	148.87
2⅞	20.48		
		8 *in.*	158.63
3 *in.*	22.35	8¼	168.15
3⅛	24.20	8½	179.08
3¼	26.18	8¾	189.00
3⅜	28.23		
3½	30.36	9 *in.*	200.77
3⅝	32.57	9¼	211.12
3¾	34.85	9½	223.70
3⅞	37.21	9¾	235.31
4 *in.*	39.66	10 *in.*	247.87
4⅛	41.80	10½	273.27
4¼	44.77		
4⅜	47.00	11 *in.*	299.92
4½	50.19	11½	327.81
4⅝	52.71	12 *in.*	356.93
4¾	55.92	13	418.90
4⅞	58.72	14	485.83

NOTE.—The area of a circle in inches, multiplied by the length in inches, and by .263 = the weight in lbs. avoirdupois of cast iron.

TABLE V,

Containing the weight of cast iron pipes, 1 foot in length.

Diam. of bore in inches.	THICKNESS IN INCHES.							
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1 *in.*	$1\frac{1}{8}$	$1\frac{1}{4}$
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
2 *in.*	8.8	12.3	16.1	20.3	......	......	......	......
$2\frac{1}{2}$	10.6	14.7	19.2	23.9	......	......	......	......
3	12.4	17.2	22.2	27.6	33.3	39.3	45.6	......
$3\frac{1}{2}$	14.2	19.6	25.3	31.3	37.6	44.2	51.1	......
4	16.1	22.1	28.4	35.0	41.9	49.1	56.6	64.4
$4\frac{1}{2}$	18.0	24.5	31.4	38.7	46.2	54.0	62.1	70.6
5	19.8	27.0	34.5	42.3	50.5	58.9	67.6	76.7
$5\frac{1}{2}$	21.6	29.5	37.6	46.0	54.8	63.8	73.2	82.8
6	23.5	31.9	40.7	49.7	59.1	68.7	78.7	88.8
$6\frac{1}{2}$	25.3	34.4	43.7	53.4	63.4	73.4	84.2	95.1
7	27.2	36.8	46.8	56.8	67.7	78.5	89.7	101.2
$7\frac{1}{2}$	29.0	39.1	49.9	60.7	72.0	83.5	95.3	107.4
8	30.8	41.7	52.9	64.4	76.2	88.4	100.8	113.5
$8\frac{1}{2}$	32.9	44.4	56.2	68.3	80.8	93.5	106.5	119.9
9	34.5	46.6	59.1	71.8	84.8	98.2	111.8	125.8
$9\frac{1}{2}$	36.3	49.1	62.1	75.5	89.1	103.1	117.4	131.9
10	38.2	51.5	65.2	79.2	93.4	108.0	122.8	138.1
$10\frac{1}{2}$	......	54.0	68.2	82.8	97.7	112.9	128.4	144.2
11	......	56.4	71.3	86.5	102.0	117.8	133.9	150.3
$11\frac{1}{2}$	......	58.9	74.3	90.1	106.3	122.7	139.4	156.4
12	......	61.3	77.4	93.6	110.6	127.6	145.0	162.6
13	......	......	82.7	101.2	118.2	137.4	154.1	173.5
14	......	......	89.3	108.2	126.5	146.2	165.3	185.2
15	......	......	95.2	115.7	135.3	156.2	176.2	198.1
16	......	......	......	123.3	143.1	166.1	187.5	211.3
17	......	......	......	130.2	152.5	178.5	198.2	223.4
18	......	......	......	137.0	161.2	185.3	209.1	235.6
19	......	......	......	......	169.2	195.7	222.3	247.1
20	......	......	......	......	178.1	205.2	233.2	259.0
21	......	......	......	......	......	214.1	243.5	273.2
22	......	......	......	......	......	223.0	254.8	285.4
23	......	......	......	......	......	233.4	265.5	298.3
24	......	......	......	......	......	245.2	277.5	310.6

TABLE VI,

Containing the weight of cast iron balls, from 3 *to* 12 *inches diameter.*

Diameter in inches.	Weight in Lbs.	Diameter in inches.	Weight in Lbs.
3	3.7	7½	58.0
3¼	4.7	7¾	64.0
3½	5.8	8	70.4
3¾	7.2	8¼	77.3
4	8.8	8½	84.5
4¼	10.5	8¾	92.2
4½	12.5	9	100.3
4¾	14.7	9¼	108.9
5	17.1	9½	118.0
5¼	19.9	9¾	127.6
5½	22.9	10	137.7
5¾	26.1	10¼	148.2
6	29.7	10½	159.4
6¼	33.6	10¾	171.0
6½	37.8	11	183.2
6¾	42.3	11½	209.4
7	47.2	12	237.9
7¼	52.4		

TABLE VII,

Containing the square and cube roots of all numbers from 1 to 1728.

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1	1.0000	1.0000	46	6.7823	3.5830
2	1.4142	1.2599	47	6.8556	3.6088
3	1.7320	1.4422	48	6.9282	3.6342
4	2.0000	1.5874	49	7.0000	3.6593
5	2.2360	1.7099	50	7.0710	3.6840
6	2.4494	1.8171	51	7.1414	3.7084
7	2.6457	1.9129	52	7.2111	3.7325
8	2.8284	2.0000	53	7.2801	3.7562
9	3.0000	2.0800	54	7.3484	3.7797
10	3.1622	2.1544	55	7.4161	3.8029
11	3.3166	2.2239	56	7.4833	3.8258
12	3.4641	2.2894	57	7.5498	3.8485
13	3.6055	2.3513	58	7.6157	3.8708
14	3.7416	2.4101	59	7.6811	3.8929
15	3.8729	2.4662	60	7.7459	3.9148
16	4.0000	2.5198	61	7.8102	3.9364
17	4.1231	2.5712	62	7.8740	3.9578
18	4.2426	2.6207	63	7.9372	3.9790
19	4.3588	2.6684	64	8.0000	4.0000
20	4.4721	2.7144	65	8.0622	4.0207
21	4.5825	2.7589	66	8.1240	4.0412
22	4.6904	2.8020	67	8.1853	4.0615
23	4.7958	2.8438	68	8.2462	4.0816
24	4.8989	2.8844	69	8.3066	4.1015
25	5.0000	2.9240	70	8.3666	4.1212
26	5.0990	2.9624	71	8.4261	4.1408
27	5.1961	3.0000	72	8.4852	4.1601
28	5.2915	3.0365	73	8.5440	4.1793
29	5.3851	3.0723	74	8.6023	4.1983
30	5.4772	3.1072	75	8.6602	4.2171
31	5.5677	3.1413	76	8.7177	4.2358
32	5.6568	3.1748	77	8.7749	4.2543
33	5.7445	3.2075	78	8.8317	4.2726
34	5.8309	3.2396	79	8.8881	4.2908
35	5.9160	3.2710	80	8.9442	4.3088
36	6.0000	3.3019	81	9.0000	4.3267
37	6.0827	3.3322	82	9.0553	4.3444
38	6.1644	3.3619	83	9.1104	4.3620
39	6.2449	3.3912	84	9.1651	4.3795
40	6.3245	3.4199	85	9.2195	4.3968
41	6.4031	3.4482	86	9.2736	4.4140
42	6.4807	3.4760	87	9.3273	4.4310
43	6.5574	3.5033	88	9.3808	4.4479
44	6.6332	3.5303	89	9.4339	4.4647
45	6.7082	3.5568	90	9.4868	4.4814

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
91	9.5393	4.4979	140	11.8321	5.1924
92	9.5916	4.5143	141	11.8743	5.2048
93	9.6436	4.5306	142	11.9163	5.2171
94	9.6953	4.5468	143	11.9582	5.2293
95	9.7467	4.5629	144	12.0000	5.2414
96	9.7979	4.5788	145	12.0415	5.2535
97	9.8488	4.5947	146	12.0830	5.2656
98	9.8994	4.6104	147	12.1243	5.2776
99	9.9498	4.6260	148	12.1655	5.2895
100	10.0000	4.6415	149	12.2065	5.3014
101	10.0498	4.6570	150	12.2474	5.3132
102	10.0995	4.6723	151	12.2882	5.3250
103	10.1488	4.6875	152	12.3288	5.3368
104	10.1980	4.7026	153	12.3693	5.3484
105	10.2469	4.7176	154	12.4096	5.3601
106	10.2956	4.7326	155	12.4498	5.3716
107	10.3440	4.7474	156	12.4899	5.3832
108	10.3923	4.7622	157	12.5299	5.3946
109	10.4403	4.7768	158	12.5698	5.4061
110	10.4880	4.7914	159	12.6095	5.4175
111	10.5356	4.8058	160	12.6491	5.4288
112	10.5830	4.8202	161	12.6885	5.4401
113	10.6301	4.8345	162	12.7279	5.4513
114	10.6770	4.8488	163	12.7671	5.4625
115	10.7238	4.8629	164	12.8062	5.4737
116	10.7703	4.8769	165	12.8452	5.4848
117	10.8166	4.8909	166	12.8840	5.4958
118	10.8627	4.9048	167	12.9228	5.5068
119	10.9087	4.9186	168	12.9614	5.5178
120	10.9544	4.9324	169	13.0000	5.5287
121	11.0000	4.9460	170	13.0384	5.5396
122	11.0453	4.9596	171	13.0766	5.5504
123	11.0905	4.9731	172	13.1148	5.5612
124	11.1355	4.9866	173	13.1529	5.5720
125	11.1803	5.0000	174	13.1909	5.5827
126	11.2249	5.0132	175	13.2287	5.5934
127	11.2694	5.0265	176	13.2664	5.6040
128	11.3137	5.0396	177	13.3041	5.6146
129	11.3578	5.0527	178	13.3416	5.6252
130	11.4017	5.0657	179	13.3790	5.6357
131	11.4455	5.0787	180	13.4164	5.6462
132	11.4891	5.0916	181	13.4536	5.6566
133	11.5325	5.1044	182	13.4907	5.6670
134	11.5758	5.1172	183	13.5277	5.6774
135	11.6189	5.1299	184	13.5646	5.6877
136	11.6619	5.1425	185	13.6014	5.6980
137	11.7046	5.1551	186	13.6381	5.7082
138	11.7473	5.1676	187	13.6747	5.7184
139	11.7898	5.1801	188	13.7113	5.7286

Numb.	*SquareRoots.*	*Cube Roots.*	*Numb.*	*SquareRoots.*	*Cube Roots.*
189	13.7477	5.7387	238	15.4272	6.1971
190	13.7840	5.7488	239	15.4596	6.2058
191	13.8202	5.7589	240	15.4919	6.2144
192	13.8564	5.7689	241	15.5241	6.2230
193	13.8924	5.7789	242	15.5563	6.2316
194	13.9283	5.7889	243	15.5884	6.2402
195	13.9642	5.7988	244	15.6204	6.2487
196	14.0000	5.8087	245	15.6524	6.2573
197	14.0356	5.8186	246	15.6843	6.2658
198	14.0712	5.8284	247	15.7162	6.2743
199	14.1067	5.8382	248	15.7480	6.2827
200	14.1421	5.8480	249	15.7797	6.2911
201	14.1774	5.8577	250	15.8113	6.2996
202	14.2126	5.8674	251	15.8429	6.3079
203	14.2478	5.8771	252	15.8745	6.3163
204	14.2828	5.8867	253	15.9059	6.3247
205	14.3178	5.8963	254	15.9373	6.3330
206	14.3527	5.9059	255	15.9687	6.3413
207	14.3874	5.9154	256	16.0000	6.3496
208	14.4222	5.9249	257	16.0312	6.3578
209	14.4568	5.9344	258	16.0623	6.3660
210	14.4913	5.9439	259	16.0934	6.3743
211	14.5258	5.9533	260	16.1245	6.3825
212	14.5602	5.9627	261	16.1554	6.3906
213	14.5945	5.9720	262	16.1864	6.3988
214	14.6287	5.9814	263	16.2172	6.4069
215	14.6628	5.9907	264	16.2480	6.4150
216	14.6969	6.0000	265	16.2788	6.4231
217	14.7309	6.0092	266	16.3095	6.4312
218	14.7648	6.0184	267	16.3401	6.4392
219	14.7986	6.0276	268	16.3707	6.4473
220	14.8323	6.0368	269	16.4012	6.4553
221	14.8660	6.0459	270	16.4316	6.4633
222	14.8996	6.0550	271	16.4620	6.4712
223	14.9331	6.0641	272	16.4924	6.4792
224	14.9666	6.0731	273	16.5227	6.4871
225	15.0000	6.0822	274	16.5529	6.4950
226	15.0332	6.0911	275	16.5831	6.5029
227	15.0665	6.1001	276	16.6132	6.5108
228	15.0996	6.1091	277	16.6433	6.5186
229	15.1327	6.1180	278	16.6733	6.5265
230	15.1657	6.1269	279	16.7032	6.5343
231	15.1986	6.1357	280	16.7332	6.5421
232	15.2315	6.1446	281	16.7630	6.5499
233	15.2643	6.1534	282	16.7928	6.5576
234	15.2970	6.1622	283	16.8226	6.5654
235	15.3297	6.1710	284	16.8522	6.5731
236	15.3622	6.1797	285	16.8819	6.5808
237	15.3948	6.1884	286	16.9115	6.5885

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
287	16.9410	6.5962	336	18.3303	6.9520
288	16.9705	6.6038	337	18.3575	6.9589
289	17.0000	6.6114	338	18.3847	6.9658
290	17.0293	6.6191	339	18.4119	6.9726
291	17.0587	6.6267	340	18.4390	6.9795
292	17.0880	6.6342	341	18.4661	6.9863
293	17.1172	6.6418	342	18.4932	6.9931
294	17.1464	6.6493	343	18.5202	7.0000
295	17.1755	6.6569	344	18.5472	7.0067
296	17.2046	6.6644	345	18.5741	7.0135
297	17.2336	6.6719	346	18.6010	7.0203
298	17.2626	6.6794	347	18.6279	7.0271
299	17.2916	6.6868	348	18.6547	7.0338
300	17.3205	6.6943	349	18.6815	7.0405
301	17.3493	6.7017	350	18.7082	7.0472
302	17.3781	6.7091	351	18.7349	7.0540
303	17.4068	6.7165	352	18.7616	7.0606
304	17.4355	6.7239	353	18.7882	7.0673
305	17.4642	6.7313	354	18.8148	7.0740
306	17.4928	6.7386	355	18.8414	7.0806
307	17.5214	6.7459	356	18.8679	7.0873
308	17.5499	6.7533	357	18.8944	7.0939
309	17.5783	6.7606	358	18.9208	7.1005
310	17.6068	6.7678	359	18.9472	7.1071
311	17.6351	6.7751	360	18.9736	7.1137
312	17.6635	6.7824	361	19.0000	7.1203
313	17.6918	6.7896	362	19.0262	7.1269
314	17.7200	6.7968	363	19.0525	7.1334
315	17.7482	6.8040	364	19.0787	7.1400
316	17.7763	6.8112	365	19.1049	7.1465
317	17.8044	6.8184	366	19.1311	7.1530
318	17.8325	6.8256	367	19.1572	7.1595
319	17.8605	6.8327	368	19.1833	7.1660
320	17.8885	6.8399	369	19.2093	7.1725
321	17.9164	6.8470	370	19.2353	7.1790
322	17.9443	6.8541	371	19.2613	7.1855
323	17.9722	6.8612	372	19.2873	7.1919
324	18.0000	6.8682	373	19.3132	7.1984
325	18.0277	6.8753	374	19.3390	7.2048
326	18.0554	6.8823	375	19.3649	7.2112
327	18.0831	6.8894	376	19.3907	7.2176
328	18.1107	6.8964	377	19.4164	7.2240
329	18.1383	6.9034	378	19.4422	7.2304
330	18.1659	6.9104	379	19.4679	7.2367
331	18.1934	6.9173	380	19.4935	7.2431
332	18.2208	6.9243	381	19.5192	7.2495
333	18.2482	6.9313	382	19.5448	7.2558
334	18.2756	6.9383	383	19.5703	7.2621
335	18.3030	6.9451	384	19.5959	7.2684

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
385	19.6214	7.2747	434	20.8326	7.5711
386	19.6468	7.2810	435	20.8566	7.5769
387	19.6723	7.2873	436	20.8806	7.5827
388	19.6977	7.2936	437	20.9045	7.5885
389	19.7230	7.2998	438	20.9284	7.5943
390	19.7484	7.3061	439	20.9523	7.6001
391	19.7737	7.3123	440	20.9761	7.6059
392	19.7989	7.3186	441	21.0000	7.6116
393	19.8242	7.3248	442	21.0237	7.6174
394	19.8494	7.3310	443	21.0457	7.6231
395	19.8746	7.3372	444	21.0713	7.6288
396	19.8997	7.3434	445	21.0950	7.6346
397	19.9248	7.3495	446	21.1187	7.6403
398	19.9499	7.3557	447	21.1423	7.6460
399	19.9749	7.3619	448	21.1660	7.6517
400	20.0000	7.3680	449	21.1896	7.6574
401	20.0249	7.3741	450	21.2132	7.6630
402	20.0499	7.3803	451	21.2367	7.6687
403	20.0748	7.3864	452	21.2602	7.6744
404	20.0997	7.3925	453	21.2837	7.6800
405	20.1246	7.3986	454	21.3072	7.6857
406	20.1494	7.4047	455	21.3307	7.6913
407	20.1742	7.4107	456	21.3541	7.6970
408	20.1990	7.4168	457	21.3775	7.7026
409	20.2237	7.4229	458	21.4009	7.7082
410	20.2484	7.4289	459	21.4242	7.7138
411	20.2731	7.4349	460	21.4476	7.7194
412	20.2977	7.4410	461	21.4709	7.7250
413	20.3224	7.4470	462	21.4941	7.7306
414	20.3469	7.4530	463	21.5174	7.7361
415	20.3715	7.4590	464	21.5406	7.7417
416	20.3960	7.4650	465	21.5638	7.7473
417	20.4205	7.4709	466	21.5870	7.7528
418	20.4450	7.4769	467	21.6101	7.7584
419	20.4694	7.4829	468	21.6333	7.7639
420	20.4939	7.4888	469	21.6564	7.7694
421	20.5182	7.4948	470	21.6794	7.7749
422	20.5426	7.5007	471	21.7025	7.7804
423	20.5669	7.5066	472	21.7255	7.7859
424	20.5912	7.5125	473	21.7485	7.7914
425	20.6155	7.5184	474	21.7715	7.7969
426	20.6397	7.5243	475	21.7944	7.8024
427	20.6639	7.5302	476	21.8174	7.8079
428	20.6881	7.5361	477	21.8403	7.8133
429	20.7123	7.5419	478	21.8632	7.8188
430	20.7364	7.5478	479	21.8860	7.8242
431	20.7605	7.5536	480	21.9089	7.8297
432	20.7846	7.5595	481	21.9317	7.8351
433	20.8086	7.5653	482	21.9544	7.8405

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
483	21.9772	7.8460	532	23.0651	8.1028
484	22.0000	7.8514	533	23.0867	8.1079
485	22.0227	7.8568	534	23.1084	8.1129
486	22.0454	7.8622	535	23.1300	8.1180
487	22.0680	7.8676	536	23.1516	8.1230
488	22.0907	7.8729	537	23.1732	8.1281
489	22.1133	7.8783	538	23.1948	8.1331
490	22.1359	7.8837	539	23.2163	8.1382
491	22.1585	7.8890	540	23.2379	8.1432
492	22.1810	7.8944	541	23.2594	8.1482
493	22.2036	7.8997	542	23.2808	8.1532
494	22.2261	7.9051	543	23.3023	8.1583
495	22.2485	7.9104	544	23.3238	8.1633
496	22.2710	7.9157	545	23.3452	8.1683
497	22.2934	7.9210	546	23.3666	8.1733
498	22.3159	7.9264	547	23.3880	8.1782
499	22.3383	7.9317	548	23.4093	8.1832
500	22.3606	7.9370	549	23.4307	8.1882
501	22.3830	7.9422	550	23.4520	8.1932
502	22.4053	7.9475	551	23.4733	8.1981
503	22.4276	7.9528	552	23.4946	8.2031
504	22.4499	7.9581	553	23.5159	8.2080
505	22.4722	7.9633	554	23.5372	8.2130
506	22.4944	7.9686	555	23.5584	8.2179
507	22.5166	7.9738	556	23.5796	8.2228
508	22.5388	7.9791	557	23.6008	8.2278
509	22.5610	7.9843	558	23.6220	8.2327
510	22.5831	7.9895	559	23.6431	8.2376
511	22.6053	7.9947	560	23.6643	8.2425
512	22.6274	8.0000	561	23.6854	8.2474
513	22.6495	8.0052	562	23.7065	8.2523
514	22.6715	8.0104	563	23.7276	8.2572
515	22.6936	8.0155	564	23.7486	8.2621
516	22.7156	8.0207	565	23.7697	8.2670
517	22.7376	8.0259	566	23.7907	8.2719
518	22.7596	8.0311	567	23.8117	8.2767
519	22.7815	8.0362	568	23.8327	8.2816
520	22.8035	8.0414	569	23.8537	8.2864
521	22.8254	8.0466	570	23.8746	8.2913
522	22.8473	8.0517	571	23.8956	8.2961
523	22.8691	8.0568	572	23.9165	8.3010
524	22.8910	8.0620	573	23.9374	8.3058
525	22.9128	8.0671	574	23.9582	8.3106
526	22.9346	8.0722	575	23.9791	8.3155
527	22.9564	8.0773	576	24.0000	8.3203
528	22.9782	8.0824	577	24.0208	8.3251
529	23.0000	8.0875	578	24.0416	8.3299
530	23.0217	8.0926	579	24.0624	8.3347
531	23.0434	8.0977	580	24.0831	8.3395

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
581	24.1039	8.3443	630	25.0998	8.5726
582	24.1246	8.3491	631	25.1197	8.5771
583	24.1453	8.3539	632	25.1396	8.5816
584	24.1660	8.3586	633	25.1594	8.5862
585	24.1867	8.3634	634	25.1793	8.5907
586	24.2074	8.3682	635	25.1992	8.5952
587	24.2280	8.3729	636	25.2190	8.5997
588	24.2487	8.3777	637	25.2388	8.6042
589	24.2693	8.3824	638	25.2586	8.6087
590	24.2899	8.3872	639	25.2784	8.6132
591	24.3104	8.3919	640	25.2982	8.6177
592	24.3310	8.3966	641	25.3179	8.6222
593	24.3515	8.4013	642	25.3377	8.6267
594	24.3721	8.4061	643	25.3574	8.6311
595	24.3926	8.4108	644	25.3771	8.6356
596	24.4131	8.4155	645	25.3968	8.6401
597	24.4335	8.4202	646	25.4165	8.6445
598	24.4540	8.4249	647	25.4361	8.6490
599	24.4744	8.4296	648	25.4558	8.6534
600	24.4948	8.4343	649	25.4754	8.6579
601	24.5153	8.4390	650	25.4950	8.6623
602	24.5356	8.4436	651	25.5147	8.6668
603	24.5560	8.4483	652	25.5342	8.6712
604	24.5764	8.4530	653	25.5538	8.6756
605	24.5967	8.4576	654	25.5734	8.6801
606	24.6170	8.4623	655	25.5929	8.6845
607	24.6373	8.4670	656	25.6124	8.6889
608	24.6576	8.4716	657	25.6320	8.6933
609	24.6779	8.4762	658	25.6515	8.6977
610	24.6981	8.4809	659	25.6709	8.7021
611	24.7184	8.4855	660	25.6904	8.7065
612	24.7386	8.4901	661	25.7099	8.7109
613	24.7588	8.4948	662	25.7293	8.7153
614	24.7790	8.4994	663	25.7487	8.7197
615	24.7991	8.5040	664	25.7681	8.7241
616	24.8193	8.5086	665	25.7875	8.7285
617	24.8394	8.5132	666	25.8069	8.7328
618	24.8596	8.5178	667	25.8263	8.7372
619	24.8797	8.5224	668	25.8456	8.7416
620	24.8997	8.5270	669	25.8650	8.7459
621	24.9198	8.5316	670	25.8843	8.7503
622	24.9399	8.5361	671	25.9036	8.7546
623	24.9599	8.5407	672	25.9229	8.7590
624	24.9799	8.5453	673	25.9422	8.7633
625	25.0000	8.5498	674	25.9615	8.7677
626	25.0199	8.5544	675	25.9807	8.7720
627	25.0399	8.5589	676	26.0000	8.7763
628	25.0599	8.5635	677	26.0192	8.7807
629	25.0798	8.5680	678	26.0384	8.7850

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
679	26.0576	8.7893	728	26.9814	8.9958
680	26.0768	8.7936	729	27.0000	9.0000
681	26.0959	8.7979	730	27.0185	9.0041
682	26.1151	8.8022	731	27.0370	9.0082
683	26.1342	8.8065	732	27.0554	9.0123
684	26.1533	8.8108	733	27.0739	9.0164
685	26.1725	8.8151	734	27.0924	9.0205
686	26.1916	8.8194	735	27.1108	9.0246
687	26.2106	8.8237	736	27.1293	9.0287
688	26.2297	8.8280	737	27.1477	9.0328
689	26.2488	8.8322	738	27.1661	9.0368
690	26.2678	8.8365	739	27.1845	9.0409
691	26.2868	8.8408	740	27.2029	9.0450
692	26.3058	8.8450	741	27.2213	9.0491
693	26.3248	8.8493	742	27.2396	9.0531
694	26.3438	8.8535	743	27.2580	9.0572
695	26.3628	8.8578	744	27.2763	9.0613
696	26.3818	8.8620	745	27.2946	9.0653
697	26.4007	8.8663	746	27.3130	9.0694
698	26.4196	8.8705	747	27.3313	9.0734
699	26.4386	8.8748	748	27.3495	9.0775
700	26.4575	8.8790	749	27.3678	9.0815
701	26.4764	8.8832	750	27.3861	9.0856
702	26.4952	8.8874	751	27.4043	9.0896
703	26.5141	8.8917	752	27.4226	9.0936
704	26.5329	8.8959	753	27.4408	9.0977
705	26.5518	8.9001	754	27.4590	9.1017
706	26.5706	8.9043	755	27.4772	9.1057
707	26.5894	8.9085	756	27.4954	9.1097
708	26.6082	8.9127	757	27.5136	9.1137
709	26.6270	8.9169	758	27.5317	9.1177
710	26.6458	8.9211	759	27.5499	9.1218
711	26.6645	8.9253	760	27.5680	9.1258
712	26.6833	8.9294	761	27.5862	9.1298
713	26.7020	8.9336	762	27.6043	9.1338
714	26.7207	8.9378	763	27.6224	9.1377
715	26.7394	8.9420	764	27.6405	9.1417
716	26.7581	8.9461	765	27.6586	9.1457
717	26.7768	8.9503	766	27.6767	9.1497
718	26.7955	8.9545	767	27.6947	9.1537
719	26.8141	8.9586	768	27.7128	9.1577
720	26.8328	8.9628	769	27.7308	9.1616
721	26.8514	8.9669	770	27.7488	9.1656
722	26.8700	8.9711	771	27.7668	9.1696
723	26.8886	8.9752	772	27.7848	9.1735
724	26.9072	8.9793	773	27.8028	9.1775
725	26.9258	8.9835	774	27.8208	9.1815
726	26.9443	8.9876	775	27.8388	9.1854
727	26.9629	8.9917	776	27.8567	9.1894

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
777	27.8747	9.1933	826	28.7402	9.3826
778	27.8926	9.1972	827	28.7576	9.3864
779	27.9105	9.2012	828	28.7749	9.3902
780	27.9284	9.2051	829	28.7923	9.3940
781	27.9463	9.2090	830	28.8097	9.3977
782	27.9642	9.2130	831	28.8270	9.4015
783	27.9821	9.2169	832	28.8444	9.4053
784	28.0000	9.2208	833	28.8617	9.4091
785	28.0178	9.2247	834	28.8790	9.4128
786	28.0356	9.2287	835	28.8963	9.4166
787	28.0535	9.2326	836	28.9136	9.4203
788	28.0713	9.2365	837	28.9309	9.4241
789	28.0891	9.2404	838	28.9482	9.4278
790	28.1069	9.2443	839	28.9654	9.4316
791	28.1247	9.2482	840	28.9827	9.4353
792	28.1424	9.2521	841	29.0000	9.4391
793	28.1602	9.2560	842	29.0172	9.4428
794	28.1780	9.2599	843	29.0344	9.4466
795	28.1957	9.2637	844	29.0516	9.4503
796	28.2134	9.2676	845	29.0688	9.4540
797	28.2311	9.2715	846	29.0860	9.4577
798	28.2488	9.2754	847	29.1032	9.4615
799	28.2665	9.2793	848	29.1204	9.4652
800	28.2842	9.2831	849	29.1376	9.4689
801	28.3019	9.2870	850	29.1547	9.4726
802	28.3196	9.2909	851	29.1719	9.4761
803	28.3372	9.2947	852	29.1890	9.4801
804	28.3548	9.2986	853	29.2061	9.4838
805	28.3725	9.3024	854	29.2232	9.4875
806	28.3901	9.3063	855	29.2403	9.4912
807	28.4077	9.3101	856	29.2574	9.4949
808	28.4253	9.3140	857	29.2745	9.4986
809	28.4429	9.3178	858	29.2916	9.5023
810	28.4604	9.3216	859	29.3087	9.5059
811	28.4780	9.3255	860	29.3257	9.5096
812	28.4956	9.3293	861	29.3428	9.5133
813	28.5131	9.3331	862	29.3598	9.5170
814	28.5306	9.3370	863	29.3768	9.5207
815	28.5482	9.3408	864	29.3938	9.5244
816	28.5657	9.3446	865	29.4108	9.5280
817	28.5832	9.3484	866	29.4278	9.5317
818	28.6006	9.3522	867	29.4448	9.5354
819	28.6181	9.3560	868	29.4618	9.5390
820	28.6356	9.3599	869	29.4788	9.5427
821	28.6530	9.3637	870	29.4957	9.5464
822	28.6705	9.3675	871	29.5127	9.5500
823	28.6879	9.3713	872	29.5296	9.5537
824	28.7054	9.3750	873	29.5465	9.5573
825	28.7228	9.3788	874	29.5634	9.5610

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
875	29.5803	9.5646	924	30.3973	9.7399
876	29.5972	9.5682	925	30.4138	9.7434
877	29.6141	9.5719	926	30.4302	9.7469
878	29.6310	9.5755	927	30.4466	9.7504
879	29.6479	9.5792	928	30.4630	9.7539
880	29.6647	9.5828	929	30.4795	9.7575
881	29.6816	9.5864	930	30.4959	9.7610
882	29.6984	9.5900	931	30.5122	9.7644
883	29.7153	9.5937	932	30.5286	9.7679
884	29.7321	9.5973	933	30.5450	9.7714
885	29.7489	9.6009	934	30.5614	9.7749
886	29.7657	9.6045	935	30.5777	9.7784
887	29.7825	9.6081	936	30.5941	9.7829
888	29.7993	9.6117	937	30.6104	9.7854
889	29.8161	9.6153	938	30.6267	9.7889
890	29.8328	9.6190	939	30.6431	9.7923
891	29.8496	9.6226	940	30.6594	9.7958
892	29.8663	9.6262	941	30.6757	9.7993
893	29.8831	9.6297	942	30.6920	9.8028
894	29.8998	9.6333	943	30.7083	9.8062
895	29.9165	9.6369	944	30.7245	9.8097
896	29.9332	9.6405	945	30.7408	9.8131
897	29.9499	9.6441	946	30.7571	9.8166
898	29.9666	9.6477	947	30.7733	9.8201
899	29.9833	9.6513	948	30.7896	9.8235
900	30.0000	9.6548	949	30.8058	9.8270
901	30.0166	9.6584	950	30.8220	9.8304
902	30.0333	9.6620	951	30.8382	9.8339
903	30.0499	9.6656	952	30.8544	9.8373
904	30.0665	9.6691	953	30.8706	9.8408
905	30.0832	9.6727	954	30.8868	9.8442
906	30.0998	9.6763	955	30.9030	9.8476
907	30.1164	9.6798	956	30.9192	9.8511
908	30.1330	9.6834	957	30.9354	9.8545
909	30.1496	9.6869	958	30.9515	9.8579
910	30.1662	9.6905	959	30.9677	9.8614
911	30.1827	9.6940	960	30.9838	9.8648
912	30.1993	9.6976	961	31.0000	9.8682
913	30.2158	9.7011	962	31.0161	9.8716
914	30.2324	9.7046	963	31.0322	9.8751
915	30.2489	9.7082	964	31.0483	9.8785
916	30.2654	9.7117	965	31.0644	9.8819
917	30.2820	9.7153	966	31.0805	9.8853
918	30.2985	9.7188	967	31.0966	9.8887
919	30.3150	9.7223	968	31.1126	9.8921
920	30.3315	9.7258	969	31.1287	9.8955
921	30.3479	9.7294	970	31.1448	9.8989
922	30.3644	9.7329	971	31.1608	9.9023
923	30.3809	9.7364	972	31.1769	9.9057

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
973	31.1929	9.9091	1022	31.9687	10.0728
974	31.2089	9.9125	1023	31.9843	10.0760
975	31.2249	9.9159	1024	32.0000	10.0793
976	31.2409	9.9193	1025	32.0156	10.0826
977	31.2569	9.9227	1026	32.0312	10.0859
978	31.2729	9.9261	1027	32.0468	10.0892
979	31.2889	9.9295	1028	32.0624	10.0924
980	31.3049	9.9328	1029	32.0780	10.0957
981	31.3209	9.9362	1030	32.0936	10.0990
982	31.3368	9.9396	1031	32.1091	10.1022
983	31.3528	9.9430	1032	32.1247	10.1055
984	31.3687	9.9463	1033	32.1403	10.1088
985	31.3847	9.9497	1034	32.1558	10.1120
986	31.4006	9.9531	1035	32.1714	10.1153
987	31.4165	9.9564	1036	32.1869	10.1185
988	31.4324	9.9598	1037	32.2024	10.1218
989	31.4483	9.9631	1038	32.2180	10.1250
990	31.4642	9.9665	1039	32.2335	10.1283
991	31.4801	9.9699	1040	32.2490	10.1315
992	31.4960	9.9732	1041	32.2645	10.1348
993	31.5119	9.9766	1042	32.2800	10.1380
994	31.5277	9.9799	1043	32.2955	10.1413
995	31.5436	9.9833	1044	32.3109	10.1445
996	31.5594	9.9866	1045	32.3264	10.1478
997	31.5753	9.9899	1046	32.3419	10.1510
998	31.5911	9.9933	1047	32.3573	10.1542
999	31.6069	9.9966	1048	32.3728	10.1575
1000	31.6227	10.0000	1049	32.3882	10.1607
1001	31.6385	10.0033	1050	32.4037	10.1639
1002	31.6543	10.0066	1051	32.4191	10.1671
1003	31.6701	10.0099	1052	32.4345	10.1704
1004	31.6859	10.0133	1053	32.4499	10.1736
1005	31.7017	10.0166	1054	32.4653	10.1768
1006	31.7175	10.0199	1055	32.4807	10.1800
1007	31.7332	10.0232	1056	32.4961	10.1832
1008	31.7490	10.0265	1057	32.5115	10.1865
1009	31.7647	10.0299	1058	32.5269	10.1897
1010	31.7804	10.0332	1059	32.5422	10.1929
1011	31.7962	10.0365	1060	32.5576	10.1961
1012	31.8119	10.0398	1061	32.5729	10.1993
1013	31.8276	10.0431	1062	32.5883	10.2025
1014	31.8433	10.0464	1063	32.6036	10.2057
1015	31.8590	10.0497	1064	32.6190	10.2089
1016	31.8747	10.0530	1065	32.6343	10.2121
1017	31.8904	10.0563	1066	32.6496	10.2153
1018	31.9061	10.0596	1067	32.6649	10.2185
1019	31.9217	10.0629	1068	32.6802	10.2217
1020	31.9374	10.0662	1069	32.6955	10.2249
1021	31.9530	10.0695	1070	32.7108	10.2280

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1071	32.7261	10.2312	1120	33.4664	10.3849
1072	32.7414	10.2344	1121	33.4813	10.3880
1073	32.7566	10.2376	1122	33.4962	10.3911
1074	32.7719	10.2408	1123	33.5111	10.3942
1075	32.7871	10.2439	1124	33.5261	10.3973
1076	32.8024	10.2471	1125	33.5410	10.4004
1077	32.8176	10.2503	1126	33.5559	10.4034
1078	32.8329	10.2535	1127	33.5708	10.4065
1079	32.8481	10.2566	1128	33.5857	10.4096
1080	32.8633	10.2598	1129	33.6005	10.4127
1081	32.8785	10.2630	1130	33.6154	10.4158
1082	32.8937	10.2661	1131	33.6303	10.4188
1083	32.9089	10.2693	1132	33.6452	10.4219
1084	32.9241	10.2725	1133	33.6600	10.4250
1085	32.9393	10.2756	1134	33.6749	10.4280
1086	32.9545	10.2788	1135	33.6897	10.4311
1087	32.9696	10.2819	1136	33.7045	10.4342
1088	32.9848	10.2851	1137	33.7194	10.4372
1089	33.0000	10.2882	1138	33.7342	10.4403
1090	33.0151	10.2914	1139	33.7490	10.4433
1091	33.0302	10.2945	1140	33.7638	10.4464
1092	33.0454	10.2977	1141	33.7786	10.4494
1093	33.0605	10.3008	1142	33.7934	10.4525
1094	33.0756	10.3039	1143	33.8082	10.4555
1095	33.0907	10.3071	1144	33.8230	10.4586
1096	33.1058	10.3102	1145	33.8378	10.4616
1097	33.1209	10.3134	1146	33.8526	10.4647
1098	33.1360	10.3165	1147	33.8673	10.4677
1099	33.1511	10.3196	1148	33.8821	10.4708
1100	33.1662	10.3228	1149	33.8969	10.4738
1101	33.1813	10.3259	1150	33.9116	10.4768
1102	33.1963	10.3290	1151	33.9263	10.4799
1103	33.2114	10.3321	1152	33.9411	10.4829
1104	33.2264	10.3352	1153	33.9558	10.4859
1105	33.2415	10.3384	1154	33.9705	10.4890
1106	33.2565	10.3415	1155	33.9852	10.4920
1107	33.2716	10.3446	1156	34.0000	10.4950
1108	33.2866	10.3477	1157	34.0147	10.4981
1109	33.3016	10.3508	1158	34.0293	10.5011
1110	33.3166	10.3539	1159	34.0440	10.5041
1111	33.3316	10.3570	1160	34.0587	10.5071
1112	33.3466	10.3602	1161	34.0734	10.5101
1113	33.3616	10.3633	1162	34.0881	10.5132
1114	33.3766	10.3664	1163	34.1027	10.5162
1115	33.3916	10.3695	1164	34.1174	10.5192
1116	33.4065	10.3726	1165	34.1320	10.5222
1117	33.4215	10.3757	1166	34.1467	10.5252
1118	33.4365	10.3788	1167	34.1613	10.5282
1119	33.4514	10.3818	1168	34.1760	10.5312

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1169	34.1906	10.5342	1218	34.8998	10.6794
1170	34.2052	10.5372	1219	34.9141	10.6823
1171	34.2198	10.5402	1220	34.9284	10.6852
1172	34.2344	10.5432	1221	34.9428	10.6882
1173	34.2490	10.5462	1222	34.9571	10.6911
1174	34.2626	10.5492	1223	34.9714	10.6940
1175	34.2782	10.5522	1224	34.9857	10.6969
1176	34.2928	10.5552	1225	35.0000	10.6998
1177	34.3074	10.5582	1226	35.0142	10.7027
1178	34.3220	10.5612	1227	35.0285	10.7056
1179	34.3365	10.5642	1228	35.0428	10.7086
1180	34.3511	10.5672	1229	35.0570	10.7115
1181	34.3656	10.5702	1230	35.0713	10.7144
1182	34.3802	10.5731	1231	35.0856	10.7173
1183	34.3947	10.5761	1232	35.0998	10.7202
1184	34.4093	10.5791	1233	35.1140	10.7231
1185	34.4238	10.5821	1234	35.1283	10.7260
1186	34.4383	10.5850	1235	35.1425	10.7289
1187	34.4528	10.5880	1236	35.1567	10.7318
1188	34.4673	10.5910	1237	35.1710	10.7346
1189	34.4818	10.5940	1238	35.1852	10.7375
1190	34.4963	10.5969	1239	35.1994	10.7404
1191	34.5108	10.5999	1240	35.2136	10.7433
1192	34.5253	10.6029	1241	35.2278	10.7462
1193	34.5398	10.6058	1242	35.2420	10.7491
1194	34.5543	10.6088	1243	35.2562	10.7520
1195	34.5687	10.6118	1244	35.2703	10.7549
1196	34.5832	10.6147	1245	35.2845	10.7577
1197	34.5976	10.6177	1246	35.2987	10.7606
1198	34.6121	10.6206	1247	35.3128	10.7635
1199	34.6265	10.6236	1248	35.3270	10.7664
1200	34.6410	10.6265	1249	35.3411	10.7693
1201	34.6554	10.6295	1250	35.3553	10.7721
1202	34.6698	10.6324	1251	35.3694	10.7750
1203	34.6842	10.6354	1252	35.3836	10.7779
1204	34.6987	10.6383	1253	35.3977	10.7807
1205	34.7131	10.6413	1254	35.4118	10.7836
1206	34.7275	10.6442	1255	35.4259	10.7865
1207	34.7419	10.6472	1256	35.4400	10.7893
1208	34.7562	10.6501	1257	35.4541	10.7922
1209	34.7706	10.6530	1258	35.4682	10.7951
1210	34.7850	10.6560	1259	35.4823	10.7979
1211	34.7994	10.6589	1260	35.4964	10.8008
1212	34.8137	10.6618	1261	35.5105	10.8036
1213	34.8281	10.6648	1262	35.5246	10.8065
1214	34.8425	10.6677	1263	35.5387	10.8093
1215	34.8568	10.6706	1264	35.5527	10.8122
1216	34.8711	10.6736	1265	35.5668	10.8150
1217	34.8855	10.6765	1266	35.5808	10.8179

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots*	*Cube Roots.*
1267	35.5949	10.8207	1316	36.2767	10.[illegible]585
1268	35.6089	10.8236	1317	36.2904	10.9612
1269	[illegible]	10.826[illegible]	1318	36.3042	10.9640
1270	35.6370	10.8293	1319	36.3[illegible]8[illegible]	10.9568
1[illegible]71	35.6[illegible]0	10.8321	1320	36.3318	10.9696
1272	35.6[illegible]1	10.8350	1321	36.3455	10.9723
1273	35.6791	10.8378	13[illegible]	36.3593	10.9751
1274	35.6931	10.8406	1323	36.3730	10.9779
1275	35.7071	10.8435	13[illegible]4	36.38[illegible]8	10.9806
1276	35 7211	10.8463	13[illegible]5	36.4005	10.9834
1277	35.7351	10.8491	13[illegible]6	36.4142	10.98[illegible]2
1278	35.7491	10.8520	1327	36.4280	10.9889
1279	35.7631	10.8548	1328	36.4417	10.9917
1280	35.7770	10.8576	13[illegible]9	35 4554	10.9944
1281	35.7910	10.8604	1330	36.4691	10.9972
1282	35.8050	10.8633	1331	36.48[illegible]8	11.0000
1283	35.8189	10.8561	1332	36.4965	11.0027
1284	35.8329	10.8689	1333	36.5102	11.0055
1285	35.8468	10.8717	1334	36.5239	11.0082
1286	35.8608	10.8746	1335	36.5376	11.0110
1287	35.8747	10.8774	1336	36.5513	11.0137
1288	35.8887	10.8802	1337	36.5650	11.0165
1289	35.9026	10.8830	1338	36.5786	11.0192
1290	35.9165	10.8858	1339	36.5923	11.0219
1291	35.9304	10.8886	1340	36.6060	11.0247
1292	35 9444	10.8914	1341	36.6196	11.0274
1293	35.9583	10.8943	1342	36.6333	11.0302
1294	35.9722	10.8971	1343	36 6469	11.0329
1295	35.9861	10.8999	1344	36.6606	11.0356
1296	36.0000	10.9027	1345	36.6742	11.0384
1297	36.0138	10.9055	1346	36.6878	11.0411
1298	36 0277	10.9083	1347	36.7014	11.0439
1299	36.0416	10.9111	1348	36.7151	11.0466
1300	36 0555	10.9139	1349	36.7287	11.0493
1301	36.0693	10.9167	1350	36.7423	11 0520
1302	36.0832	10 9195	1351	36.7559	11.0548
1303	36.0970	10.9223	1352	36 7695	11.0575
1304	36.1109	10.9251	1353	36.7831	11.0602
1305	36.1247	10.9279	1354	36.7967	11.0629
1306	36.1386	10.9306	1355	36.8103	11.0657
1307	36.1524	10.9334	1356	36.8239	11.0684
1308	36.1662	10.9362	1357	36.8374	11.0711
13[illegible]9	36.18[illegible]1	10.9390	1358	36.8510	11.0738
1310	36.1939	10.9418	1359	36.8646	11.0766
131[illegible]	36.2077	10.9446	1360	36.8781	11.0793
1312	36.2215	10.9474	1361	36.8917	11.0820
1313	36.2353	10.9501	1[illegible]6[illegible]	36.9052	11.0847
1314	36.2491	10.9529	1363	36.9188	11.0874
1315	36.2629	10.9557	1364	36.9323	11.0901

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1365	36.9459	11.0928	1414	37.6031	11.2240
1366	36.9594	11.0955	1415	37.6164	11.2267
1367	36.9729	11.0982	1416	37.6297	11.2293
1368	36.9864	11.1009	1417	37.64[illegible]0	11.2319
1369	37.0000	11.1037	1418	37.6563	11.2346
1370	37.0135	11.1064	1419	37.6696	11.2372
1371	37.[illegible]70	11.1091	1420	37.6828	11.2399
1372	37.0405	11.1118	1421	37.6961	11.2425
1373	37.0[illegible]	11.1145	1422	37.7094	11.2451
1374	37.0675	11.1172	1423	37.7226	11.2478
1375	37.0809	11.1199	1424	37.7359	11.2504
1376	37.0944	11.1225	1425	37.7491	11.2530
1377	37.1079	11.1252	1426	37.7624	11.2557
1378	37.1214	11.1279	1427	37.7756	11.2583
1379	37.1348	11.1306	1428	37.7888	11.2609
1380	37.1483	11.1333	1429	37.8021	11.2636
1381	37.1618	11.1360	1430	37.8153	11.2662
1382	37.1752	11.1387	1431	37.8285	11.2688
1383	37.1887	11.1414	1432	37.8417	11.2714
1384	37.2021	11.1441	1433	37.8549	11.2741
1385	37.2155	11.1467	14[illegible]4	37.8681	11.2767
1386	37.2290	11.1494	1435	37.8813	11.2793
1387	37.2424	11.1521	1436	37.[illegible]945	11.2819
1388	37.2558	11.1548	1437	37.9077	11.2845
1389	37.2692	11.1575	1438	37.9209	11.2872
1390	37.2827	11.1601	1439	37.9341	11.2898
1391	37.2961	11.1628	1440	37.9473	11.2924
1392	37.3095	11.1655	1441	37.9605	11.2950
1393	37.3229	11.1682	1442	37.9736	11.2976
1394	37.33[illegible]3	11.1708	1443	37.9868	11.3002
1395	37.3496	11.1735	1444	38.0000	11.3028
1396	37.3630	11.1762	1445	38.0131	11.3054
1397	37.3764	11.1788	1446	38.0263	11.3080
1398	37.3898	11.1815	1447	38.0394	11.3107
1399	37.4032	11.1842	1448	38.0525	11.3133
1400	37.4165	11.1868	1449	38.0657	11.3159
1401	37.4299	11.1895	1450	38.0788	11.3185
1402	37.44[illegible]2	11.1922	1451	38.0919	11.3211
1403	37.4[illegible]66	11.1948	1452	38.1051	11.3237
1404	37.4699	11.1975	1453	38.1182	11.3263
1405	37.4833	11.2001	1454	38.1313	11.3289
1406	37.4966	11.2028	1455	38.1444	11.3315
1407	37.5099	11.2055	1456	38.1575	11.3341
1408	37.5233	11.2081	1457	38.1706	11.3366
1409	37.5366	11.2108	1458	38.1837	11.3392
1410	37.5499	11.2134	1459	38.1968	11.3418
1411	37.5632	11.2161	1460	38.2099	11.3444
1412	37.5765	11.2187	1461	38.2[illegible]30	11.3470
1413	37.5898	11.2214	1462	38.2361	11.3496

Numb.	*Square Roots.*	*Cube Roots.*	*Numb*	*Square Roots.*	*Cube Roots.*
1463	38.2491	11.3522	1512	38.8844	11.4775
1464	38.2622	11.3548	1513	38.8973	11.4801
1465	38.2753	11.3574	1514	38.9101	11.4826
1466	38.2883	11.3599	1515	38.9230	11.4851
1467	38.3014	11.3625	1516	38.9358	11.4876
1468	38.3144	11.3651	1517	38.9486	11.4902
1469	38.3275	11.3677	1518	38.9615	11·4927
1470	38.3405	11.3703	1519	38.9743	11.4952
1471	38.3536	11.3728	1520	38.9871	11.4977
1472	38.3666	11.3754	1521	39.0000	11.5003
1473	38.3796	11.3780	1522	39.0128	11.5028
1474	38.3927	11.3806	1523	39.0256	11.5053
1475	38.4057	11.3831	1524	39.0384	11.5078
1476	38.4187	11.3857	1525	39.0512	11.5103
1477	38.4317	11.3883	1526	39.0640	11.5129
1478	38.4447	11.3909	1527	39.0768	11.5154
1479	38.4577	11.3934	1528	39.0896	11.5179
1480	38.4707	11.3960	1529	39.1024	11.5204
1481	38.4837	11.3986	1530	39.1152	11.5229
1482	38.4967	11.4011	1531	39.1279	11.5254
1483	38.5097	11.4037	1532	39.1407	11.5279
1484	38.5227	11.4062	1533	39.1535	11.5304
1485	38.5356	11.4088	1534	39.1663	11.5329
1486	38.5486	11.4114	1535	39.1790	11.5354
1487	38.5616	11.4139	1536	39.1918	11.5379
1488	38.5746	11.4165	1537	39.2045	11.5404
1489	38.5875	11.4190	1538	39.2173	11 5430
1490	38.6005	11.4216	1539	39.2300	11.5455
1491	38.6134	11.4242	1540	39.2428	11.5480
1492	38.6264	11.4267	1541	39.2555	11.5505
1493	38.6393	11.4293	1542	39.2683	11.5530
1494	38.6522	11.4318	1543	39.2810	11.5554
1495	38.6652	11.4344	1544	39.2937	11.5579
1496	38.6781	11.4369	1545	39.3064	11.5604
1497	38.6910	11.4395	1546	39.3192	11.5629
1498	38.7040	11.4420	1547	39.3319	11.5654
1499	38.7169	11.4445	1548	39.3446	11.5679
1500	38.7298	11.4471	1549	39.3573	11.5704
1501	38.7427	11.4496	1550	39.3700	11.5729
1502	38.7556	11.4522	1551	39.3827	11.5754
1503	38.7685	11.4547	1552	39.3954	11.5779
1504	38.7814	11.4573	1553	39.4081	11.5804
1505	38.7943	11.4598	1554	39.4208	11.5828
1506	38.8072	11.4623	1555	39.4334	11.5853
1507	38.8200	11.4649	1556	39 4461	11.5878
1508	38.8329	11.4674	1557	39.4588	11.5903
1509	38.8458	11.4699	1558	39.4715	11.5928
1510	38.8587	11.4725	1559	39.4841	11.5953
1511	38.8715	11.4750	1560	39.4968	11.5977

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1561	39.5094	11.6002	1610	40.1248	11.7203
1562	39.5221	11.6027	1611	40.1372	11.7228
1563	39.5347	11.6052	1612	40.1497	11.7252
1564	39.5474	11.6076	1613	40.1621	11.7276
1565	39.5600	11.6101	1614	40.1746	11.7300
1566	39.5727	11.6126	1615	40.1870	11.7325
1567	39.5853	11.6151	1616	40.1995	11.7349
1568	39.5979	11.6175	1617	40.2119	11.7373
1569	39.6106	11.6200	1618	40.2243	11.7397
1570	39.6232	11.6225	1619	40.2367	11.7421
1571	39.6358	11.6249	1620	40.2492	11.7446
1572	39.6484	11.6274	1621	40.2616	11.7470
1573	39.6610	11.6299	1622	40.2740	11.7494
1574	39.6736	11.6323	1623	40.2864	11.7518
1575	39.6862	11.6348	1624	40.2988	11.7542
1576	39.6988	11.6372	1625	40.3112	11.7566
1577	39.7114	11.6397	1626	40.3236	11.7590
1578	39.7240	11.6422	1627	40.3360	11.7614
1579	39.7366	11.6446	1628	40.3484	11.7639
1580	39.7492	11.6471	1629	40.3608	11.7663
1581	39.7617	11.6495	1630	40.3732	11.7687
1582	39.7743	11.6520	1631	40.3856	11.7711
1583	39.7869	11.6544	1632	40.3980	11.7735
1584	39.7994	11.6569	1633	40.4103	11.7759
1585	39.8120	11.6594	1634	40.4227	11.7783
1586	39.8246	11.6618	1635	40.4351	11.7807
1587	39.8371	11.6643	1636	40.4474	11.7831
1588	39.8497	11.6667	1637	40.4598	11.7855
1589	39.8622	11.6692	1638	40.4722	11.7879
1590	39.8748	11.6716	1639	40.4845	11.7903
1591	39.8873	11.6740	1640	40.4969	11.7927
1592	39.8998	11.6765	1641	40.5092	11.7951
1593	39.9124	11.6789	1642	40.5215	11.7975
1594	39.9249	11.6814	1643	40.5339	11.7999
1595	39.9374	11.6838	1644	40.5462	11.8023
1596	39.9499	11.6863	1645	40.5585	11.8047
1597	39.9624	11.6887	1646	40.5709	11.8071
1598	39.9749	11.6911	1647	40.5832	11.8094
1599	39.9874	11.6936	1648	40.5955	11.8118
1600	40.0000	11.6960	1649	40.6078	11.8142
1601	40.0124	11.6985	1650	40.6201	11.8166
1602	40.0249	11.7009	1651	40.6324	11.8190
1603	40.0374	11.7033	1652	40.6448	11.8214
1604	40.0499	11.7058	1653	40.6571	11.8238
1605	40.0624	11.7082	1654	40.6693	11.8261
1606	40.0749	11.7106	1655	40.6816	11.8285
1607	40.0874	11.7131	1656	40.6939	11.8309
1608	40.0998	11.7155	1657	40.7062	11.8333
1609	40.1123	11.7179	1658	40.7185	11.8357

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
1659	40.7308	11.8381	1694	41.1582	11.9207
1660	40.7430	11.8404	1695	41.1703	11.9231
1661	40.7553	11.8428	1696	41.1825	11.9254
1662	40.7676	11.8452	1697	41.1946	11.9278
1663	40.7798	11.8476	1698	41.2067	11.9301
1664	40.7921	11.8499	1699	41.2189	11.9324
1665	40.[illegible]044	11.8523	1700	41.2310	11.9348
1666	40.8166	11.8547	1701	41.2431	11.9371
1667	40.8289	11.8571	1702	41.2553	11.9395
1668	40.8411	11.8594	1703	41.2674	11.9418
1669	40.85[illegible]3	11.8618	1704	41.2795	11.9441
1670	40.8656	11.8642	1705	41.2916	11.9465
1671	40.8778	11.8665	1706	41.3037	11.9488
1672	40.8900	11.8689	1707	41.3158	11.9511
1673	40.9023	11.8713	1708	41.3279	11.9535
1674	40.9145	11.8736	1709	41 3400	11.9558
1675	40.9267	11.8760	1710	41.3521	11.9581
1676	40.9389	11.8784	1711	41.3642	11.9605
1677	40.9511	11.8807	1712	41.3763	11.9628
1678	40.9633	11.8831	1713	41.3884	11.9651
1679	40.9756	11.8854	1714	41.4004	11.9675
1680	40.9878	11.8878	1715	41.4125	11.9698
1681	41.0000	11.8902	1716	41.4246	11.9721
1682	41.0121	11.8925	1717	41.4366	11.9744
1683	41.0243	11.8949	1718	41.4487	11.9768
1684	41.0365	11.8972	1719	41.4608	11.9791
1685	41.0487	11.8996	1720	41.4728	11.9814
1686	41.0609	11.9019	1721	41.4849	11.9837
1687	41.0731	11.9043	1722	41.4969	11.9860
1688	41.0852	11.9066	1723	41.5090	11.9884
1689	41.0974	11.9090	1724	41.5210	11.9907
1690	41.1096	11.9113	1725	41.5331	11.9930
1691	41.1217	11.9137	1726	41.5451	11.9953
1692	41.1339	11.9160	1727	41.5571	11.9976
1693	41.1460	11.9184	1728	41.5692	12.0000

TABLE VIII,

Containing the circumferences, squares, cubes, and areas of circles, from 1 to 100, advancing by a tenth.

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
1	3.1416	1	1	.7854
.1	3.4557	1.21	1.331	.9503
.2	3.7699	1.44	1.728	1.1309
.3	4.0840	1.69	2.197	1.3273
.4	4.3982	1.96	2.744	1.5393
.5	4.7124	2.25	3.375	1.7671
.6	5.0265	2.56	4.096	2.0106
.7	5.3407	2.89	4.913	2.2698
.8	5.6548	3.24	5.832	2.5446
.9	5.9690	3.61	6 859	2.8352
2	6.2832	4	8	3.1416
.1	6.5973	4.41	9.261	3.4636
.2	6.9115	4.84	10.648	3.8013
.3	7.2256	5.29	12.167	4 1547
.4	7.5398	5 76	13 824	4.5239
.5	7.8540	6.25	15 625	4.9087
.6	8.1681	6.76	17.576	5.3093
.7	8.4823	7.29	19.683	5.7255
.8	8.7964	7.84	21.952	6.1575
.9	9.1106	8.41	24.389	6.6052
3	9.4248	9	27	7.0686
.1	9.7389	9.61	29.791	7.5476
.2	10.0531	10.24	32.768	8.0424
.3	10.3672	10.89	35.937	8.5530
.4	10.6814	11.56	39.304	9.0792
.5	10.9956	12.25	42.875	9.6211
.6	11.3097	12.96	46.656	10.1787
.7	11.6239	13.69	50.653	10.7521
.8	11.9380	14.44	54.872	11.3411
.9	12.2522	15.21	59.319	11.9459
4	12.5664	16	64	12.5664
.1	12.8805	16.81	68.921	13.2025
.2	13 1947	17.64	74.088	13.8544
.3	13.5088	18.49	79.507	14.5220
.4	13.8230	19.36	85.184	15.2053
.5	14.1372	20.25	91.125	15.9043
.6	14.4513	21.16	97.336	16.6190
.7	14.7655	22.09	103.823	17.3494
.8	15.0796	23.04	110 592	18 0956
.9	15.3938	24.01	117.649	18.8574

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
15	47.1240	225.	3375	176.7150
.1	47.4381	228.01	3442.951	179.0790
.2	47.7523	231.04	3511.808	181.4588
.3	48.0664	234.09	3581.577	183.8542
.4	48.3806	237.16	3652.264	186.2654
.5	48.6948	240.25	3723.875	188.6923
.6	49.0089	243.36	3796.416	191.1349
.7	49.3231	246.49	3869.893	193.5932
.8	49.6372	249.64	3944.312	196.0672
.9	49.9514	252.81	4019.679	198.5569
16	50.2656	256.	4096.	201.0624
.1	50.5797	259.21	4173.281	203.5835
.2	50.8939	262.44	4251.528	206.1203
.3	51.2080	265.69	4330.747	208.6729
.4	51.5224	268.96	4410.944	211.2411
.5	51.8364	272.25	4492.125	213.8251
.6	52.1505	275.56	4574.296	216.4248
.7	52.4647	278.89	4657.463	219.0402
.8	52.7788	282.24	4741.632	221.6712
.9	53.0930	285.61	4826.809	224.3180
17	53.4072	289.	4913.	226.9806
.1	53.7213	292.41	5000.211	229.6588
.2	54.0355	295.84	5088.448	232.3527
.3	54.3496	299.29	5177.717	235.0623
.4	54.6038	302.76	5268.024	237.7877
.5	54.9780	306.25	5359.375	240.5287
.6	55.2921	309.76	5451.776	243.2855
.7	55.6063	313.29	5545.233	246.0579
.8	55.9204	316.84	5639.752	248.8461
.9	56.2346	320.41	5735.339	251.6500
18	56.5488	324.	5832.	254.4696
.1	56.8629	327.61	5929.741	257.3048
.2	57.1771	331.24	6028.568	260.1558
.3	57.4912	334.89	6128.487	263.0226
.4	57.8054	338.56	6229.504	265.9050
.5	58.1196	342.25	6331.625	268.8031
.6	58.4337	345.96	6434.856	271.7169
.7	58.7479	349.69	6539.203	274.6465
.8	59.0620	353.44	6644.672	277.5917
.9	59.3762	357.21	6751.269	280.5527
19	59.6904	361.	6859.	283.5294
.1	60.0045	364.81	6967.871	286.5217
.2	60.3187	368.64	7077.888	289.5298
.3	60.6328	372.49	7189.057	292.5536
.4	60.9470	376.36	7301.384	295.5931
.5	61.2612	380.25	7414.875	298.6483
.6	61.5753	384.16	7529.536	301.7192
.7	61.8895	388.09	7645.373	304.8060
.8	62.2036	392.04	7762.392	307.9082
.9	62.5178	396.01	7880.599	311.0252

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
20	62.8320	400	8000	314.1600
.1	63.1461	404.01	8120.601	317.3094
.2	63.4603	408.04	8242.408	320.4746
.3	63.7744	412.09	8365.427	323.6554
.4	64.0886	416.16	8489.664	326.8520
.5	64.4028	420.25	8615.125	330.0643
.6	64.7161	424.36	8741.816	333.2923
.7	65.0311	428 49	8869.743	336.5360
.8	65.3452	432.64	8998.912	339 7954
.9	65.6594	436.81	9129.329	343.0705
21	65.9736	441	9261	346.3614
.1	66.2877	445.21	9393.931	349 6679
.2	66.6019	449.44	9528.128	352.9901
.3	66 9160	453.69	9663.597	356.3281
.4	67.2302	457.96	9800.344	359.6817
.5	67.5444	462.25	9938.375	363.0511
.6	67.8585	466.56	10077.696	366.4362
.7	68.1727	470.89	10218.313	369.8370
.8	68.4868	475.24	10360.232	373.2534
.9	68.8010	479.61	10503.459	376.6856
22	69 1152	484	10648	380.1336
.1	69.4293	488.41	10793.861	383.5972
.2	69.7435	492.84	10941.048	387.0765
.3	70.0576	497.29	11089.567	390.5751
.4	70.3718	501.76	11239.424	394 0823
.5	70.6860	506.25	11390.625	397.6087
.6	71.0001	510.76	11543.176	401.1509
.7	71.3143	515.29	11697.083	404.7087
.8	71.6284	519.84	11852.352	408.2823
.9	71.9426	524.41	12008.989	411.8716
23	72.2568	529	12167	415.4766
.1	72.5709	533.61	12326.391	419.0972
.2	72.8851	538.24	12487.168	422.7336
.3	73.1992	542.89	12649.337	426.3858
.4	73.5134	547.56	12812.904	430.0536
.5	73.8276	552.25	12977.875	433.7371
.6	74.1417	556.96	13144.256	437.4363
.7	74.4559	561.69	13312.053	441 1511
.8	74.7680	566.44	13481.272	444.8819
.9	75.0882	571.21	13651.919	448.6283
24	75.3984	576	13824	452.3904
.1	75.7125	580.81	13997.521	456.1681
.2	76.0267	585.64	14172.488	459.9616
.3	76.3408	590.49	14348.907	463 7708
.4	76.6523	595.36	14526.784	467.5957
.5	76.9692	600.25	14706.125	471 4363
.6	77.2833	605.16	14886.936	475.2926
.7	77.5975	610.09	15069.223	479.1646
.8	77.9116	615.04	15252.992	483 0524
.9	78.2258	620.01	15438.249	486.9558

Diam.	Circum.	Square.	Cube.	Area.
15	47.1240	225.	3375	176.7150
.1	47.4381	228.01	3442.951	179.0790
.2	47.7523	231.04	3511.808	181.4588
.3	48.0664	234.09	3581.577	183.8542
.4	48.3806	237.16	3652.264	186.2654
.5	48.6948	240.25	3723.875	188.6923
.6	49.0089	243.36	3796.416	191.1349
.7	49.3231	246.49	3869.893	193.5932
.8	49.6372	249.64	3944.312	196.0672
.9	49.9514	252.81	4019.679	198.5569
16	50.2656	256.	4096.	201.0624
.1	50.5797	259.21	4173.281	203.5835
.2	50.8939	262.44	4251.528	206.1203
.3	51.2080	265.69	4330.747	208.6729
.4	51.5224	268.96	4410.944	211.2411
.5	51.8364	272.25	4492.125	213.8251
.6	52.1505	275.56	4574.296	216.4248
.7	52.4647	278.89	4657.463	219.0402
.8	52.7788	282.24	4741.632	221.6712
.9	53.0930	285.61	4826.809	224.3180
17	53.4072	289.	4913.	226.9806
.1	53.7213	292.41	5000.211	229.6588
.2	54.0355	295.84	5088.448	232.3527
.3	54.3496	299.29	5177.717	235.0623
.4	54.6038	302.76	5268.024	237.7877
.5	54.9780	306.25	5359.375	240.5287
.6	55.2921	309.76	5451.776	243.2855
.7	55.6063	313.29	5545.233	246.0579
.8	55.9204	316.84	5639.752	248.8461
.9	56.2346	320.41	5735.339	251.6500
18	56.5488	324.	5832.	254.4696
.1	56.8629	327.61	5929.741	257.3048
.2	57.1771	331.24	6028.568	260.1558
.3	57.4912	334.89	6128.487	263.0226
.4	57.8054	338.56	6229.504	265.9050
.5	58.1196	342.25	6331.625	268.8031
.6	58.4337	345.96	6434.856	271.7169
.7	58.7479	349.69	6539.203	274.6465
.8	59.0620	353.44	6644.672	277.5917
.9	59.3762	357.21	6751.269	280.5527
19	59.6904	361.	6859.	283.5294
.1	60.0045	364.81	6967.871	286.5217
.2	60.3187	368.64	7077.888	289.5298
.3	60.6328	372.49	7189.057	292.5536
.4	60.9470	376.36	7301.384	295.5931
.5	61.2612	380.25	7414.875	298.6483
.6	61.5753	384.16	7529.536	301.7192
.7	61.8895	388.09	7645.373	304.8060
.8	62.2036	392.04	7762.392	307.9082
.9	62.5178	396.01	7880.599	311.0252

Diam.	Circum.	Square.	Cube.	Area.
20	62.8320	400	8000	314.1600
.1	63.1461	404.01	8120.601	317.3094
.2	63.4603	408.04	8242.408	320.4746
.3	63.7744	412.09	8365.427	323.6554
.4	64.0886	416.16	8489.664	326.8520
.5	64.4028	420.25	8615.125	330.0643
.6	64.7161	424.36	8741.816	333.2923
.7	65.0311	428.49	8869.743	336.5360
.8	65.3452	432.64	8998.912	339.7954
.9	65.6594	436.81	9129.329	343.0705
21	65.9736	441	9261	346.3614
.1	66.2877	445.21	9393.931	349.6679
.2	66.6019	449.44	9528.128	352.9901
.3	66.9160	453.69	9663.597	356.3281
.4	67.2302	457.96	9800.344	359.6817
.5	67.5444	462.25	9938.375	363.0511
.6	67.8585	466.56	10077.696	366.4362
.7	68.1727	470.89	10218.313	369.8370
.8	68.4868	475.24	10360.232	373.2534
.9	68.8010	479.61	10503.459	376.6856
22	69.1152	484	10648	380.1336
.1	69.4293	488.41	10793.861	383.5972
.2	69.7435	492.84	10941.048	387.0765
.3	70.0576	497.29	11089.567	390.5751
.4	70.3718	501.76	11239.424	394.0823
.5	70.6860	506.25	11390.625	397.6087
.6	71.0001	510.76	11543.176	401.1509
.7	71.3143	515.29	11697.083	404.7087
.8	71.6284	519.84	11852.352	408.2823
.9	71.9426	524.41	12008.989	411.8716
23	72.2568	529	12167	415.4766
.1	72.5709	533.61	12326.391	419.0972
.2	72.8851	538.24	12487.168	422.7336
.3	73.1992	542.89	12649.337	426.3858
.4	73.5134	547.56	12812.904	430.0536
.5	73.8276	552.25	12977.875	433.7371
.6	74.1417	556.96	13144.256	437.4363
.7	74.4559	561.69	13312.053	441.1511
.8	74.7680	566.44	13481.272	444.8819
.9	75.0882	571.21	13651.919	448.6283
24	75.3984	576	13824	452.3904
.1	75.7125	580.81	13997.521	456.1681
.2	76.0267	585.64	14172.488	459.9616
.3	76.3408	590.49	14348.907	463.7708
.4	76.6523	595.36	14526.784	467.5957
.5	76.9692	600.25	14706.125	471.4363
.6	77.2833	605.16	14886.936	475.2926
.7	77.5975	610.09	15069.223	479.1646
.8	77.9116	615.04	15252.992	483.0524
.9	78.2258	620.01	15438.249	486.9558

Diam	*Circum.*	*Square.*	*Cube.*	*Area.*
25	78.5400	625	15625	490.8750
.1	78.8541	630.01	15813.251	494.8098
.2	79.1683	635.04	16003.008	493.7604
.3	79.4824	640.09	16194.277	502.7266
.4	79.7966	645.16	16387.064	506.7086
.5	80.8108	650.25	16581.375	510.7063
.6	80.4249	655.36	16777.216	514.7196
.7	80.7391	660.49	16974.593	518.7488
.8	81.0532	665.64	17173.512	522.7936
.9	81.3674	670.81	17373.979	526.8541
26	81.6816	676	17576	530.9304
.1	81.9976	681.21	17779.581	535.0223
.2	82.3099	686.44	17984.728	539.1299
.3	82.6240	691.69	18191.447	543.2533
.4	82.9382	696.96	18399.744	547.3923
.5	83.2524	702.25	18609.625	551.5471
.6	83.5665	707.56	18821.096	555.7176
.7	83.8807	712.89	19034.163	559.9038
.8	84.1948	718.24	19248.832	564.1056
.9	84.5090	723.61	19465.109	568.3232
27	84.8232	729	19683	572.5566
.1	85.1373	734.41	19902.511	576.8056
.2	85.4515	739.84	20123.648	581.0703
.3	85.7656	745.29	20346.417	585.3507
.4	86.0798	750.76	20570.824	589.6469
.5	86.3940	756.25	20796.875	593.9587
.6	86.7081	761.76	21024.576	598.2863
.7	87.0223	767.29	21253.933	602.6295
.8	87.3364	772.84	21484.952	606.9885
.9	87.6506	778.41	21717.639	611.3632
28	87.9648	784	21952	615.7536
.1	88.2789	789.61	22188.041	620.1596
.2	88.5931	795.24	22425.768	624.5814
.3	88.9072	800.89	22665.187	629.0190
.4	89.2214	806.56	22906.304	633.4722
.5	89.5356	812.25	23149.125	637.9411
.6	89.8497	817.96	23393.656	642.4257
.7	90.1639	823.69	23639.903	646.9261
.8	90.4780	829.44	23887.872	651.4421
.9	90.7922	835.21	24137.569	655.9739
29	91.1064	841	24389	660.5214
.1	91.4205	846.81	24642.171	665.0845
.2	91.7347	852.64	24897.088	669.6634
.3	92.0488	858.49	25153.757	674.2580
.4	92.3630	864.36	25412.184	678.8683
.5	92.6772	870.25	25672.375	683.4943
.6	92.9913	876.16	25934.336	688.1360
.7	93.3055	882.09	26198.073	692.7934
.8	93.6196	888.04	26463.592	697.4666
.9	93.9338	894.01	26730.899	702.1554

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
30	94.2480	900	27000	706.8600
.1	94.5621	906.01	27270.901	711.5802
.2	94.8763	912.04	27543.608	716.3162
.3	95.1904	918.09	27818.127	721.0678
.4	95.5046	924.16	28094.464	725.8352
.5	95.8188	930.25	28372.625	730.6183
.6	96.1329	936.36	28652.616	735.4171
.7	96.4471	942.49	28934.443	740.2316
.8	96.7612	948.64	29218.112	745.0618
.9	97.0754	954.81	29503.629	749.9077
31	97.3896	961	29791	754.7694
.1	97.7037	967.21	30080.231	759.6467
.2	98.0179	973.44	30371.328	764.5397
.3	98.3320	979.69	30664.297	769.4485
.4	98.6452	985.96	30959.144	774.3729
.5	98.9604	992.25	31255.875	779.3131
.6	99.2745	998.56	31554.496	784.2689
.7	99.5887	1004.89	31855.013	789.2406
.8	99.9028	1011.24	32157.432	794.2278
.9	100.2170	1017.61	32461.759	799.2308
23	100.5312	1024	32768	804.2496
.1	100.8453	1030.41	33076.161	809.2840
.2	101.1595	1036.84	33386.248	814.3341
.3	101.4736	1043.29	33698.267	819.3999
.4	101.7478	1049.76	34012.224	824.4815
.5	102.1020	1056.25	34328.125	829.5787
.6	102.4161	1062.76	34645.976	834.6917
.7	102.7303	1069.29	34965.783	839.8203
.8	103.0444	1075.84	35287.552	844.9647
.9	103.3586	1082.41	35611.289	850.1248
33	103.6728	1089	35937	855.3006
.1	103.9869	1095.61	36264.691	860.4920
.2	104.3011	1102.24	36594.368	865.6992
.3	104.6151	1108.89	36926.037	870.9222
.4	104.9294	1115.56	37259.704	876.1608
.5	105.2436	1122.25	37595.375	881.4151
.6	105.5577	1128.96	37933.056	886.6851
.7	105.8719	1135.69	38272.753	891.9709
.8	106.1860	1142.44	38614.472	897.2723
.9	106.5002	1149.21	38958.219	902.5895
34	106.8144	1156	39304	907.9224
.1	107.1285	1162.81	39651.821	913.2709
.2	107.4272	1169.64	40001.688	918.6352
.3	107.7568	1176.49	40353.607	924.0115
.4	108.0710	1183.36	40707.584	929.4109
.5	108.3852	1190.25	41063.625	934.8223
.6	108.6993	1197.16	41421.736	940.2494
.7	109.0352	1204.09	41781.923	945.6922
.8	109.3076	1211.04	42144.192	951.1508
.9	109.6418	1218.01	42508.549	956.6250

Diam.	Circum.	Square.	Cube.	Area.
35	109.9560	1225	42875	962.1150
.1	110.2701	1232.01	43243.551	967.6206
.2	110.5843	1239.04	43614.208	973.1420
.3	110.8984	1246.09	43986.977	978.6790
.4	111.2126	1253.16	44361.864	984.2318
.5	111.5268	1260.25	44738.875	989.8003
.6	111.8409	1267.36	45118.016	995.3845
.7	112.1551	1274.49	45499.293	1000.9843
.8	112.4692	1281.64	45882.712	1006.6000
.9	112.7834	1288.81	46268.279	1012.2313
36	113.0976	1296	46656	1017.8784
.1	113.4117	1303.21	47045.831	1023.5411
.2	113.7259	1310.44	47437.928	1029.2195
.3	114.0400	1317.69	47832.147	1034.9131
.4	114.3542	1324.96	48228.544	1040.6235
.5	114.6684	1332.25	48627.125	1046.3491
.6	114.9825	1339.56	49027.896	1052.0904
.7	115.2967	1346.89	49430.863	1057.8474
.8	115.6108	1354.24	49836.032	1063.6200
.9	115.9250	1361.61	50243.409	1069.4084
37	116.2392	1369	50653	1075.2126
.1	116.5533	1376.41	51064.811	1081.0324
.2	116.8675	1383.84	51478.848	1086.8679
.3	117.1816	1391.29	51895.117	1092.7191
.4	117.4958	1398.76	52313.624	1098.5862
.5	117.8100	1406.25	52734.375	1104.4687
.6	118.1241	1413.76	53157.376	1110.3671
.7	118.4383	1421.29	53582.633	1116.2811
.8	118.7524	1428.84	54010.152	1122.2109
.9	119.0666	1436.41	54439.939	1128.1564
38	119.3808	1444	54872	1134.1176
.1	119.6949	1451.61	55306.341	1140.0946
.2	120.0091	1459.24	55742.968	1146.0870
.3	120.3232	1466.89	56181.887	1152.0954
.4	120.6374	1474.56	56623.104	1158.1194
.5	120.9516	1482.25	57066.625	1164.1591
.6	121.2657	1489.96	57512.456	1170.2145
.7	121.5799	1497.69	57960.603	1176.2857
.8	121.8940	1505.44	58411.072	1182.3725
.9	122.2082	1513.21	58863.869	1188.4651
39	122.5224	1521	59319	1294.5394
.1	122.8365	1528.81	59776.471	1200.7273
.2	123.1507	1536.64	60236.288	1206.8770
.3	123.4648	1544.49	60698.457	1213.0424
.4	123.7790	1552.36	61162.984	1219.2243
.5	124.0932	1560.25	61629.875	1225.4203
.6	124.4073	1568.16	62099.136	1231.6328
.7	124.7215	1576.09	62570.773	1237.8610
.8	125.0356	1584.04	63044.792	1244.1210
.9	125.3498	1592.01	63521.199	1250.3646

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
40	125.6640	1600	64000	1256.6400
.1	125.9781	1608.01	64481.201	1262.9310
.2	126.2923	1616.04	64964.808	1269.2388
.3	126.6064	1624.09	65450.827	1275.5602
.4	126.9206	1632.16	65939.264	1281.8984
.5	127.2348	1640.25	66430.125	1288.2523
.6	127.5489	1648.36	66923.416	1294.6219
.7	127.8631	1656.49	67419.143	1301.0071
.8	128.1772	1664.64	67917.312	1307.4082
.9	128.4914	1672.81	68417.929	1313.8249
41	128.8056	1681	68921	1320.2574
.1	129.1197	1689.21	69426.531	1326.7055
.2	129.4323	1697.44	69934.528	1333.1693
.3	129.7480	1705.69	70444.997	1339.6489
.4	130.0622	1713.96	70957.944	1346.1441
.5	130.3764	1722.25	71473.375	1352.6551
.6	130.6905	1730.56	71991.296	1359.1818
.7	131.0047	1738.89	72511.713	1365.7242
.8	131.3188	1747.24	73034.632	1372.2822
.9	131.6320	1755.61	73560.059	1378.8560
42	131.9472	1764	74088	1385.4456
.1	132.2613	1772.41	74618.461	1392.0508
.2	132.5755	1780.84	75151.448	1398.6717
.3	132.8896	1789.29	75686.967	1405.3083
.4	133.2038	1797.76	76225.024	1411.9607
.5	133.5180	1806.25	76765.625	1418.6287
.6	133.8321	1814.76	77308.776	1425.3125
.7	134.1463	1823.29	77854.483	1432.0119
.8	134.4604	1831.84	78402.752	1438.7271
.9	134.7746	1840.41	78953.589	1445.4580
43	135.0888	1849	79507	1452.2046
.1	135.4029	1857.61	80062.991	1458.9668
.2	135.7171	1866.24	80621.568	1465.7448
.3	136.0332	1874.89	81182.737	1472.5385
.4	136.3454	1883.56	81746.504	1479.3480
.5	136.6596	1892.25	82312.875	1486.1731
.6	136.9737	1900.96	82881.856	1493.0139
.7	137.2879	1909.69	83453.453	1499.8705
.8	137.6020	1918.44	84027.672	1506.7427
.9	137.9162	1927.21	84604.519	1513.6287
44	138.2304	1936	85184	1520.5344
.1	138.5445	1944.81	85766.121	1527.4537
.2	138.8587	1953.64	86350.888	1534.3888
.3	139.1728	1962.49	86938.307	1541.3396
.4	139.4870	1971.36	87528.384	1548.3061
.5	139.8012	1980.25	88121.125	1555.2883
.6	140.1153	1989.16	88716.536	1562.2862
.7	140.4295	1998.09	89314.623	1569.2998
.8	140.7436	2007.04	89915.392	1576.3292
.9	141.0578	2016.01	90518.849	1583.3742

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
45	141.3720	2025	91125	1590.4350
.1	141.6861	2034.01	91733.851	1597.5114
.2	142.0003	2043.04	92345.408	1604.6036
.3	142.3144	2052.09	92959.677	1611.7114
.4	142.6286	2061.16	93576.664	1618.8350
.5	142.9428	2070.25	94196.375	1625.9743
.6	143.2569	2079.36	94818.816	1633.1293
.7	143.5711	2088.49	95443.993	1640.3020
.8	143.8852	2097.64	96071.912	1647.4864
.9	144.1994	2106.81	96702.579	1654.6885
46	144.5136	2116	97336	1661.9064
.1	144.8277	2125.21	97972.181	1669.1399
.2	145.1419	2134.44	98611.128	1676.3891
.3	145.4560	2143.69	99252.847	1683.6541
.4	145.7702	2152.96	99897.344	1690.9347
.5	146.0844	2162.25	100544.625	1698.2311
.6	146.3985	2171.56	101194.696	1705.5432
.7	146.7127	2180.89	101847.563	1712.8710
.8	147.0268	2190.24	102503.232	1720.2144
.9	147.3410	2199.61	103161.709	1727.5736
47	147.6552	2209	103823	1734.9486
.	147.9693	2218.41	104487.111	1742.3392
.2	148.2835	2227.84	105154.048	1749.7455
.3	148.5976	2237.29	105823.817	1757.1675
.4	148.9118	2246.76	106496.424	1764.6045
.5	149.2260	2256.25	107171.875	1772.0587
.6	149.5361	2265.76	107850.176	1779.5279
.7	149.8543	2275.29	108531.333	1787.0127
.8	150.1684	2284.84	109215.352	1794.5133
.9	150.4826	2294.41	109902.239	1802.0296
48	150.7968	2304	110592	1809.5616
.1	151.1109	2313.61	111284.641	1817.1092
.2	151.4251	2323.24	111980.168	1824.6726
.3	151.7392	2332.89	112678.587	1832.2518
.4	152.0534	2342.56	113379.904	1839.8466
.5	152.3676	2352.25	114084.125	1847.4571
.6	152.6817	2361.96	114791.256	1855.0833
.7	152.9959	2371.69	115501.303	1862.7253
.8	153.3100	2381.44	116214.272	1870.3829
.9	153.6242	2391.21	116930.169	1878.0563
49	153.9384	2401	117649	1885.7454
.1	154.2525	2410.81	118370.771	1893.4501
.2	154.5667	2420.64	119095.488	1901.1706
.3	154.8808	2430.49	119823.157	1908.9068
.4	155.1950	2440.36	120553.784	1916.6587
.5	155.5092	2450.25	121287.375	1924.4263
.6	155.8233	2460.16	122023.936	1932.2096
.7	156.1375	2470.09	122763.473	1940.0085
.8	156.4516	2480.04	123505.992	1947.8234
.9	156.7658	2490.01	124251.499	1955.6538

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
50	157.0800	2500	125000	1963.5000
.1	157.3941	2510.01	125751.501	1971.3618
.2	157.7083	2520.04	126506.008	1979.2394
.3	158.0224	2530.09	127263.527	1987.1326
.4	158.3366	2540.16	128024.064	1995.0416
.5	158.6508	2550.25	128787.625	2002.9663
.6	158.9649	2560.36	129554.216	2010.9067
.7	159.2791	2570.49	130323.843	2018.8628
.8	159.5932	2580.64	131096.512	2026.8346
.9	159.9074	2590 81	131872.229	2034.8770
51	160.2216	2601	132651	2042.8254
.1	160.5357	2611.21	133432.831	2050.8443
.2	160.8499	2621.44	134217.728	2058.8784
.3	161.1640	2631.69	135005.697	2066.9293
.4	161.4782	2641.96	135796.744	2074.9953
.5	161.7924	2652.25	136590.875	2083.0771
.6	162.1065	2662.56	137388.096	2091.1746
.7	162.4207	2672.89	138188.413	2099.2878
.8	162.7348	2683.24	138991.832	2107.4166
.9	163.0490	2693.61	139798.359	2115.5612
52	163.3632	2704	140608	2123.7216
.1	163 6773	2714.41	141420.761	2131.8976
.2	163.9935	2724.84	142236.648	2140.0893
.3	164.3056	2735.29	143055.667	2148.2967
.4	164.6198	2745.76	143877.824	2156.5199
.5	164.9340	2756.25	144703.125	2164.7587
.6	165.2481	2766.76	145531.576	2173.0133
.7	165.5623	2777.29	146363.183	2181.2835
.8	165.8764	2787.84	147197.952	2189.5695
.9	166.1906	2798.41	148035.889	2197.8712
53	166.5048	2809	148877	2206.1886
.1	166.8189	2819.61	149721.291	2214.5216
.2	167.1331	2830.24	150568.768	2222.8704
.3	167.4472	2840.89	151419.437	2231.2350
.4	167.7614	2851.56	152273.304	2239.6152
.5	168.0756	2862.25	153130.375	2248.0111
.6	168.3897	2872.96	153990.656	2256.4227
.7	168.7049	2883.69	154854.153	2264.8701
.8	169.0180	2894.44	155720.872	2273.2931
.9	169.3322	2905.21	156590.819	2281.7519
54	169.6464	2916	157464	2290.2264
.1	169.9605	2926.81	158340.421	2298.7165
.2	170.2747	2937.64	159220.088	2307.2224
.3	170.5888	2948.49	160103.007	2315.7440
.4	170.9030	2959.36	160989.184	2324.2813
.5	171.2172	2970.25	161878.625	2332.8343
.6	171.5313	2981.16	162771.336	2341.4030
.7	171.8455	2992.09	163667.323	2349.9874
.8	172.1596	3003.04	164566.592	2358.5876
.9	172.4738	3014.01	165469.149	2367.2034

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
55	172.7880	3025	166375	2375.8350
.1	173.1021	3036.01	167284.151	2384.4822
.2	173.4163	3047.04	168196.608	2393.1452
.3	173.7304	3058.09	169112.377	2401.8238
.4	174.0446	3069.16	170031.464	2410.5182
.5	174.3588	3080.25	170953·875	2419.2283
.6	174.6729	3091.36	171879.616	2427.9541
.7	174.9771	3102.49	172808.693	2436.6956
.8	175.3092	3113.64	173741.112	2445.4528
.9	175.6154	3124.81	174676.879	2454.2257
56	175.9296	3136	175616	2463.0144
1	176.2437	3147.21	176558.481	2471.8187
.2	176.5579	3158.44	177504.328	2480.6387
.2	176.8720	3169.69	178453.547	2489.4745
.4	177.1862	3180.96	179406.144	2498.3259
.5	177.5004	3192.25	180362.125	2507.1931
.6	177.8145	3203.56	181321.496	2516.0760
.7	178.1287	3214 89	182284.263	2524.9736
.8	178.4428	3226.24	183250.432	2533.8888
.9	178.7570	3237.61	184220.009	2542.8188
57	179.0712	3249	185193	2551.7646
.1	179.3853	3260.41	186169.411	2560.7260
.2	179.6995	3271.84	187149 248	2569.7031
.2	180.0136	3283.29	188132.517	2578.6959
.4	180.3278	3294.76	189119.224	2587.7045
.5	180.6420	3306.25	190109.375	2596.7287
. 6	180.9561	3317.76	191102.976	2605.7687
.7	181.2803	3329.29	192100.033	2614.8243
.8	181.5844	3340.84	193100.552	2623.8957
.9	181.8986	3352.41	194104.539	2632.9828
58	182.2128	3364	195112	2642.0856
.1	182.5269	3375.61	196122.941	2651.2046
.2	182.8411	3387.24	197137.368	2660.3382
.3	183.1552	3398.89	198155.287	2669.4882
.4	183.4694	3410.56	199176.704	2678.6538
.5	183.7836	3422.25	200201.625	2687.8351
.6	184.0977	3433.96	201230.056	2697.0321
.7	184.4119	3445.69	202262.003	2706.2449
.8	184.7260	3457.44	203297.472	2715.4733
.9	185.0402	3469.21	204336.469	2724.7175
59	185.3544	3481	205379	2733.9774
.1	185.6685	3492.81	206425.071	2743.2529
.3	185.9827	3504.64	207474.688	2752.5442
.3	186.2696	3516.49	208527.857	2761.8512
4	186.6110	3528.36	209584.584	2771.1739
.5	186.9252	3540.25	210644.875	2780.5123
.6	187.2393	3552.16	211708.736	2789.8664
.7	187.5535	3564.09	212776.173	2799.2362
.8	187.8676	3576.04	213847.192	2808.6218
.9	188.1818	3588.01	214921.799	2818.0230

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
60	188.4960	3600	216000	2827.4400
.1	188.8101	3612.01	217081.801	2836.8726
.2	189.1243	3624.04	218167.208	2846.3210
.3	189.4384	3636.09	219256.227	2855.7850
.4	189.7526	3648.16	220348.864	2865.2648
.5	190.0668	3660.25	221445.125	2874.7603
.6	190.3809	3672.36	222545.016	2884.2615
.7	190.6951	3684.49	223648.543	2893.7984
.8	191.0092	3696.64	224755.712	2903.3410
.9	191.3234	3708.81	225866.529	2912.8993
61	191.6376	3721	226981	2922.4734
.1	191.9517	3733.21	228099.131	2932.0631
.2	192.2659	3745.44	229220.928	2941.6685
.3	192.5800	3757.69	230346.397	2951.2897
.4	192.8942	3769.96	231475.544	2960.9265
.5	193.2084	3782.25	232608.375	2970.5791
.6	193.5225	3794.56	233744.896	2980.2474
.7	193.8367	3806.89	234885.113	2989.9314
.8	194.1508	3819.24	236029.032	2999.6300
.9	194.4650	3831.61	237176.659	3009.3464
62	194.7792	3844	238328	3019.0776
.1	195.0933	3856.41	239483.061	3028.8244
.2	195.4075	3868.84	240641.848	3038.5869
.3	195.7216	3881.29	241804.367	3048.3651
.4	196.0358	3893.76	242970.624	3058.1591
.5	196.3500	3906.25	244140.625	3067.9687
.6	196.6641	3918.76	245314.376	3077.7941
.7	196.9783	3931.29	246491.883	3087.6341
.8	197.2924	3943.84	247673.152	3097.4919
.9	197.6066	3956.41	248858.189	3107.3644
63	197.9208	3969	250047	3117.2526
.1	198.2349	3981.61	251239.591	3127.1564
.2	198.5491	3994.24	252435.968	3137.0758
.3	198.8632	4006.89	253636.137	3147.0114
.4	199.1774	4019.56	254840.104	3156.9664
.5	199.4916	4032.25	256047.875	3166.9291
.6	199.8057	4044.96	257259.456	3176.9115
.7	200.1199	4057.69	258474.853	3186.9097
.8	200.4340	4070.44	259694.072	3196.9235
.9	200.7482	4083.21	260917.119	3206.9531
64	201.0624	4096	262144	3216.9984
.1	201.3765	4108.81	263374.721	3227.0593
.2	201.6907	4121.64	264609.288	3237.1360
.3	202.0048	4134.49	265847.707	3247.2284
.4	202.3190	4147.36	267089.984	3257.3365
.5	202.6332	4160.25	268336.125	3267.4603
.6	202.9473	4173.16	269586.136	3277.5998
.7	203.2615	4186.09	270840.023	3287.7550
.8	203.5756	4199.04	272097.792	3297.9260
.9	203.8898	4212.01	273359.449	3308.1126

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
65	204.2040	4225	274625	3318.3150
.1	204.5181	4238.01	275894.451	3328.5340
.2	204.8323	4251.04	277167.808	3338.7668
.3	205.1464	4264.09	278445.077	3349.0162
.4	205.4606	4277.16	279726.264	3359.2814
.5	205.7748	4290.25	281011.375	3369.5623
.6	206.0889	4303.36	282300.416	3379.8589
.7	206.4031	4316.49	283593.393	3390.1712
.8	206.7172	4329.64	284890.312	3400.4992
.9	207.0314	4342.81	286191.179	3410.8429
66	207.3456	4356	287496	3421.2024
.1	207.6597	4369.21	288804.781	3431.5775
.2	207.9739	4382.44	290117.528	3441.9633
.3	208.2880	4395.69	291434.247	3452.3749
.4	208.6022	4408.96	292754.944	3462.7971
.5	208.9164	4422.25	294079.625	3473.2351
.6	209.2305	4435.56	295408.296	3483.6888
.7	209.5447	4448.89	296740.963	3494.1640
.8	209.8588	4462.24	298077.632	3504.6432
.9	210.1730	4475.61	299418.309	3515.1430
67	210.4872	4489	300763	3525.6606
.1	210.8013	4502.41	302111.711	3536.1928
.2	211.1155	4515.84	303464.448	3546.7407
.3	211.4296	4529.29	304821.217	3557.3043
.4	211.7438	4542.76	306182.024	3567.8837
.5	212.0580	4556.25	307546.875	3578.4787
.6	212.3721	4569.76	308915.776	3589.0895
.7	212.6863	4583.29	310288.733	3599.7159
.8	213.0004	4596.84	311665.752	3610.3581
.9	213.3146	4610.41	313046.839	3621.0160
68	213.6288	4624	314432	3631.6896
.1	213.9429	4637.61	315821.241	3642.3788
.2	214.2571	4651.24	317214.568	3653.0838
.3	214.5712	4664.89	318611.987	3663.8040
.4	214.8854	4678.56	320013.504	3674.5410
.5	215.1996	4692.25	321419.125	3685.2931
.6	215.5137	4705.96	322828.856	3696.0060
.7	215.8279	4719.69	324242.703	3706.8445
.8	216.1420	4733.44	325660.672	3717.6437
.9	216.4562	4747.21	327082.769	3728.4587
69	216.7704	4761	328509	3739.2894
.1	217.0845	4774.81	329939.371	3750.1357
.2	217.3987	4788.64	331373.888	3760.9978
.3	217.7128	4802.49	332812.557	3771.8756
.4	218.0270	4816.36	334255.384	3782.7691
.5	218.3412	4830.25	335702.375	3793.6783
.6	218.6553	4844.16	337153.536	3804.6032
.7	218.9695	4858.09	338608.873	3815.5438
.8	219.2836	4872.04	340068.392	3826.5002
.9	219.5978	4886.01	341532.099	3837.4722

Diam.	Circum.	Square.	Cube.	Area.
70	219.9120	4900	343000	3848.4600
.1	220.2261	4914.01	344472.101	3859.4952
.2	220.5403	4928.04	345948.408	3870.4826
.3	220.8544	4942.09	347428.927	3881.5174
.4	221.1686	4956.16	348913.664	3892.5680
.5	221.4828	4970.25	350402.625	3903.6343
.6	221.7969	4984.36	351895.816	3914.7163
.7	222.1111	4998.49	353393.243	3925.8140
.8	222.4252	5012.64	354894.912	3936.9274
.9	222.7394	5026.81	356400.829	3948.0565
71	223.0536	5041	357911	3959.2014
.1	223.3677	5055.21	359425.431	3970.3619
.2	223.6819	5069.44	360944.128	3981.5381
.3	223.9960	5083.69	362467.097	3992.7301
.4	224.3102	5097.96	363994.344	4003.9373
.5	224.6244	5112.25	365525.875	4015.1611
.6	224.9385	5126.56	367061.696	4026.4002
.7	225.2527	5140.89	368601.813	4037.6550
.8	225.5668	5155.24	370146.232	4048.9254
.9	225.8810	5169.61	371694.959	4060.2116
72	226.1952	5184	373248	4071.5136
.1	226.5093	5198.41	374805.361	4082.8332
.2	226.8235	5212.84	376367.048	4094.1645
.3	227.1376	5227.29	377933.067	4105.5125
.4	227.4518	5241.76	379503.424	4116.8793
.5	227.7660	5256.25	381078.125	4128.2587
.6	228.0801	5270.76	382657.176	4139.6524
.7	228.3943	5285.29	384240.583	4151.0667
.8	228.7084	5299.84	385828.352	4162.4943
.9	229.0226	5314.41	387420.489	4173.9376
73	229.3368	5329	389017	4185.3966
.1	229.6509	5343.61	390617.891	4196.8712
.2	229.9651	5358.24	392223.168	4208.3614
.3	230.2792	5372.89	393832.837	4219.8678
.4	230.5934	5387.56	395446.904	4231.3896
.5	230.9076	5402.25	397065.375	4242.9271
.6	231.2217	5416.96	398688.256	4254.4803
.7	231.5359	5431.69	400315.553	4266.0493
.8	231.8500	5446.44	401947.272	4277.6339
.9	232.1642	5461.21	403583.419	4289.2343
74	232.4784	5476	405224	4300.8504
.1	232.7925	5490.81	406869.021	4312.4821
.2	233.1067	5505.64	408518.488	4324.1296
.3	233.4208	5520.49	410172.407	4335.7928
.4	233.7350	5535.36	411830.784	4347.4717
.5	234.0492	5550.25	413493.625	4359.1663
.6	234.3633	5565.16	415160.936	4370.8766
.7	234.6775	5580.09	416832.723	4382.6026
.8	234.9916	5595.04	418508.992	4394.3448
.9	235.3058	5610.01	420189.749	4406.1018

Diam.	Circum.	Square.	Cube.	Area.
75	235.6200	5625	421875	4417.8750
.1	235.9341	5640.01	423564.751	4429.6638
.2	236.2483	5655.04	425259.008	4441.4684
.3	236.5624	5670.09	426957.777	4453.2886
.4	236.8766	5685.16	428661.064	4465.1246
.5	237.1908	5700.25	430368.875	4476.9763
.6	237.5049	5715.36	432081.216	4488.8437
.7	237.8191	5730.49	433798.093	4500.7268
.8	238.1332	5745.64	435519.512	4512.6256
.9	238.4474	5760.81	437245.479	4524.5401
76	238.7616	5776	438976	4536.4704
.1	239.0757	5791.21	440711.081	4548.4163
.2	239.3899	5806.44	442450.728	4560.3787
.3	239.7040	5821.69	444194.947	4572.3553
.4	240.0182	5836.96	445943.744	4584.3583
.5	240.3324	5852.25	447697.125	4596.3571
.6	240.6465	5867.56	449455.096	4608.3816
.7	240.9607	5882.89	451217.663	4620.4218
.8	241.2748	5898.24	452984.832	4632.4776
.9	241.5987	5913.61	454756.609	4644.5492
77	241.9032	5929	456533	4656.6366
.1	242.2173	5944.41	458314.011	4668.7396
.2	242.5315	5959.84	460099.648	4680.8583
.3	242.8456	5975.29	461889.917	4692.9927
.4	243.1598	5990.76	463684.824	4705.1429
.5	243.4740	6006.25	465484.375	4717.3087
.6	243.7881	6021.76	467288.576	4729.4903
.7	244.1023	6037.29	469097.433	4741.6875
.8	244.4164	6052.84	470910.952	4753.9605
.9	244.7306	6068.41	472729.139	4766.1292
78	245.0448	6084	474552	4778.3736
.1	245.3589	6099.61	476379.541	4790.6336
.2	245.6731	6115.24	478211.768	4802.9094
.3	245.9872	6130.89	480048.687	4815.2010
.4	246.3014	6146.56	481890.304	4827.5082
.5	246.6156	6162.25	483736.625	4839.8311
.6	246.9297	6177.96	485587.656	4852.1697
.7	247.2439	6193.69	487443.403	4864.5241
.8	247.5480	6209.44	489303.872	4876.8973
.9	247.8722	6225.21	491169.069	4889.2799
79	248.1864	6241	493039	4901.6814
.1	248.5005	6256.81	494913.671	4914.0985
.2	248.8147	6272.64	496793.088	4926.5314
.3	249.1288	6288.49	498677.257	4938.9820
.4	249.4430	6304.36	500566.184	4951.4443
.5	249.7572	6320.25	502459.875	4963.9243
.6	250.0713	6336.16	504358.336	4976.4840
.7	250.3855	6352.09	506261.573	4988.9314
.8	250.6996	6368.04	508169.592	5001.4586
.9	251.0138	6384.01	510082.399	5014.0014

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
80	251.3280	6400	512000	5026.5600
.1	251.6421	6416.01	513922.401	5039.1342
.2	251.9563	6432.04	515849.608	5051.7242
.3	252.2704	6448.09	517781.627	5064.3298
.4	252.5846	6464.16	519718.464	5076.9552
.5	252.8988	6480.25	521660.125	5089.5883
.6	253.2129	6496.36	523606.616	5102.2411
.7	253.5271	6512.49	525557.943	5114.9096
.8	253.8412	6528.64	527514.112	5127.5938
.9	254.1554	6544.81	529475.129	5140.2937
81	254.4696	6561	531441	5153.0094
.1	254.7837	6577.21	533411.731	5165.7407
.2	255.0979	6593.44	535387.328	5178.4877
.3	255.4120	6609.69	537367.797	5191.2505
.4	255.7262	6625.96	539353.144	5204.0285
.5	256.0404	6642.25	541343.375	5216.8231
.6	256.3545	6658.56	543338.496	5229.6330
.7	256.6687	6674.89	545338.513	5242.4586
.8	256.9828	6691.24	547343.432	5255.2998
.9	257.2970	6707.61	549353.259	5268.1568
82	257.6112	6724	551368	5281.0296
.1	257.9253	6740.41	553387.661	5293.9180
.2	258.2395	6756.84	555412.248	5306.8221
.3	258.5536	6773.29	557441.767	5319.7439
.4	258.8646	6789.76	559476.224	5332.6775
.5	259.1820	6806.25	561515.625	5345.6287
.6	259.4961	6822.76	563559.976	5358.5957
.7	259.8103	6839.29	565609.283	5371.5983
.8	260.1244	6855.84	567663.552	5384.5762
.9	260.4386	6872.41	569722.789	5397.5908
83	260.7528	6889	571787	5410.6206
.1	261.0669	6905.61	573856.191	5423.6660
.2	261.3811	6922.24	575930.368	5436.7272
.3	261.6952	6938.89	578009.537	5449.8042
.4	262.0094	6955.56	580093.704	5462.8968
.5	262.3236	6972.25	582182.875	5476.0051
.6	262.6376	6988.96	584277.056	5489.1291
.7	262.9519	7005.69	586376.253	5502.2689
.8	263.2640	7022.44	588480.472	5515.4243
.9	263.5802	7039.21	590589.719	5528.5958
84	263.8944	7056	592704	5541.7824
.1	264.2085	7072.81	594823.321	5554.9849
.2	264.5227	7089.64	596947.688	5568.2032
.3	264.8368	7106.49	599077.107	5581.4372
.4	265.1510	7123.36	601211.584	5294.6869
.5	265.4652	7140.25	603351.125	5607.9523
.6	265.7793	7157.16	605495.736	5621.2334
.7	266.0935	7174.09	607645.423	5634.5682
.8	266.4076	7191.04	609800.192	5647.8428
.9	266.7218	7208.01	611960.04	5661.1710

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
85	267.0360	7225	614125	5674.5150
.1	267.3501	7242.01	616295.051	5687.8746
.2	267.6643	7259.04	618470.208	5701.2500
.3	267.9784	7276.09	620650.477	5714.6410
.4	268.2926	7293.16	622835.864	5728.0478
.5	268.6068	7310.25	625026.375	5741.4703
.6	268.9209	7327.36	627222.016	5754.9085
.7	269.2351	7344.49	629422.793	5768.3624
.8	269.5492	7361.64	631628.712	5781.8320
.9	269.8634	7378.81	633839.779	5795.3173
86	270.1776	7396	636056	5808.8184
.1	270.4917	7413.21	638277.381	5822.3351
.2	270.8059	7430.44	640503.928	5835.8675
.3	271.1200	7447.69	642735.647	5849.4157
.4	271.4342	7464.96	644972.544	5862.9795
.5	271.7484	7482.25	647214.625	5876.5591
.6	272.0665	7499.56	649461.896	5890.1541
.7	272.3767	7516.89	651714.363	5903.7654
.8	272.6908	7534.24	653972.032	5917.3920
.9	273.0050	7551.61	656234.909	5931.0344
87	273.3192	7569.	658503	5944.6926
.1	273.6333	7586.41	660776.311	5958.3644
.2	273.9875	7603.84	663054.848	5972.0559
.3	274.2616	7621.29	665338.617	5985.7691
.4	274.5758	7638.76	667627.624	5999.4821
.5	274.8900	7656.25	669921.875	6013.2187
.6	275.2041	7673.76	672221.376	6026.9711
.7	275.5183	7691.29	674526.133	6040.7391
.8	275.8324	7708.84	676836.152	6054.5149
.9	276.1466	7726.41	679151.439	6068.3224
88	276.4608	7744	681472	6082.1376
.1	276.7749	7761.61	683797.841	6095.9684
.2	277.0891	7779.24	686128.968	6109.8150
.3	277.4032	7796.89	688465.387	6123.6774
.4	277.7174	7814.56	690807.104	6137.5554
.5	278.0316	7832.25	693154.125	6151.4491
.6	278.3457	7849.96	695506.456	6165.3585
.7	278.6599	7867.69	697864.103	6179.2837
.8	278.9750	7885.44	700227.072	6193.2245
.9	279.2882	7903.21	702595.369	6207.1811
89	279.6024	7921	704969	6221.1534
.1	279.9165	7938.81	707347.971	6235.1413
.2	280.2307	7956.64	709732.288	6249.1450
.3	280.5448	7974.49	712121.957	6263.1644
.4	280.8590	7992.36	714516.984	6277.1995
.5	281.1732	8010.25	716917.375	6291.2035
.6	281.4873	8028.16	719323.136	6305.3168
.7	281.8825	8046.09	721734.273	6319.3990
.8	282.1156	8064.04	724150.792	6333.4970
.9	282.4298	8082.01	726572.699	6347.6813

Diam.	Circum.	Square.	Cube.	Area.
90	282.7440	8100	729000	6361.7400
.1	283.0581	8118.01	731432.701	6375.8850
.2	283.3723	8136.04	733870.808	6390.0458
.3	283.6864	8154.09	736314.327	6404.2222
.4	284.0006	8172.16	738763.264	6418.4144
.5	284.3148	8190.25	741217.625	6432.6223
.6	284.6289	8208.36	743677.416	6446.8474
.7	284.9431	8226.49	746142.643	6461.0852
.8	285.2572	8244.64	748613.312	6475.3402
.9	285.5714	8262.81	751089.429	6489.6109
91	285.8856	8281	753571	6503.8974
.1	286.1997	8299.21	756058.031	6518.1995
.2	286.5139	8317.44	758550.528	6532.5173
.3	286.8290	8335.69	761048.497	6546.8909
.4	287.1422	8353.96	763551.944	6561.2081
.5	287.4564	8372.25	766060.875	6575.5651
.6	287.7705	8390.56	768575.296	6589.9458
.7	288.0847	8408.89	771095.213	6604.3222
.8	288.3988	8427.24	773620.632	6618.7542
.9	288.7130	8445.61	776151.559	6633.1820
92	289.0272	8464	778688	6647.6256
.1	289.3413	8482.41	781229.961	6662.0848
.2	289.6555	8500.84	783777.448	6676.5597
.3	289.9696	8519.29	786330.467	6691.0161
.4	290.2838	8537.76	788889.024	6705.5567
.5	290.5980	8556.25	791453.125	6720.0787
.6	290.9121	8574.76	794022.776	6734.6165
.7	291.2263	8593.29	796597.983	6749.1699
.8	291.5404	8611.84	799178.752	6763.7391
.9	291.8546	8630.41	801765.089	6778.3240
93	292.1688	8649	804357	6792.9246
.1	292.4829	8667.61	806954.491	6807.5408
.2	292.7971	8686.24	809557.568	6822.1730
.3	293.1112	8704.89	812166.237	6836.8206
.4	293.4254	8723.56	814780.504	6851.4840
.5	293.7396	8742.25	817400.375	6866.1631
.6	294.0537	8760.96	820025.856	6880.8579
.7	294.3679	8779.69	822656.953	6895.5685
.8	294.6820	8798.44	825293.672	6910.2947
.9	294.9962	8817.21	827936.019	6925.0367
94	295.3104	8836	830584	6939.7944
.1	295.6245	8854.81	833237.621	6954.5677
.2	295.9387	8873.64	835896.888	6969.3568
.3	296.2436	8892.49	838561.807	6984.1614
.4	296.5670	8911.36	841232.384	6998.9821
.5	296.8812	8930.25	843908.625	7013.8183
.6	297.1953	8949.16	846590.536	7028.6702
.7	297.5095	8968.09	849278.123	7043.5025
.8	297.8236	8987.04	851971.392	7058.4180
.9	298.1378	9006.01	854670.349	7073.3202

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
95	298.4520	9025	857375	7088.2350
.1	298.7661	9044.01	860085.351	7103.1654
.2	299.0723	9063.04	862801.408	7118.1116
.3	299.3944	9082.09	865523.177	7133.0734
.4	299.7086	9101.16	868250.664	7148.0510
.5	300.0228	9120.25	870983.875	7163.0443
.6	300.3369	9139.36	873722.816	7178.0533
.7	300.6511	9158.49	876467.493	7193.0780
.8	300.9652	9177.64	879217.912	7208.1184
.9	301.2794	9196.81	881974.079	7223.1745
96	301.5936	9216	884736	7238.2464
.1	301.9077	9235.21	887503.681	7253.3339
.2	302.2219	9254.44	890277.128	7268.4371
.3	302.5360	9273.69	893056.347	7283.5561
.4	302.8502	9292.96	895841.344	7298.6907
.5	303.1644	9312.25	898632.125	7313.8411
.6	303.4785	9331.56	901428.696	7329.0072
.7	303.7927	9350.89	904231.063	7344.1890
.8	304.1068	9370.24	907039.232	7359.3864
.9	304.4210	9389.61	909853.209	7374.5996
97	304.7352	9409	912673	7389.8286
.1	305.0493	9428.41	915498.611	7405.0732
.2	305.3635	9447.84	918330.048	7420.3335
.3	305.6776	9467.29	921167.317	7435.6095
.4	305.9918	9486.76	924010.424	7450.9013
.5	306.3060	9506.25	926859.375	7466.2087
.6	306.6201	9525.76	929714.176	7481.5319
.7	306.9363	9545.29	932574.833	7496.8707
.8	307.2484	9564.84	935441.352	7512.2253
.9	307.5626	9584.41	938313.739	7527.5956
98	307.8768	9604	941192	7542.9816
.1	308.1909	9623.61	944076.141	7558.3832
.2	308.5051	9643.24	946966.168	7573.8006
.3	308.8192	9662.89	949862.087	7589.2338
.4	309.1334	9682.56	952763.904	7604.6826
.5	309.4476	9702.25	955671.625	7620.1471
.6	309.7617	9721.96	958585.256	7635.6273
.7	310.0759	9741.69	961504.803	7651.1933
.8	310.3960	9761.44	964430.272	7666.6349
.9	310.7042	9781.21	967361.669	7682.1623
99	311.0184	9801	970299	7697.7054
.1	311.3325	9820.81	973242.271	7713.2641
.2	311.6467	9840.64	976191.488	7728.8386
.3	311.9608	9860.49	979146.657	7744.4288
.4	312.2750	9880.36	982107.784	7760.0347
.5	312.5892	9900.25	985074.875	7775.6563
.6	312.9033	9920.16	988047.936	7791.2936
.7	313.2175	9940.09	991026.973	7806.9466
.8	313.5116	9960.04	994011.992	7822.6154
.9	313.8458	9980.01	997002.999	7838.2998
	314.1600	10000	1000000	7854.0000

TABLE II.

Containing the circumferences and areas of circles, from one-eighth to 100 inches, advancing by an eighth.

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
			5 *in.*	15.7080	19.6350
1/8	.3927	.0122	1/8	16.1007	20.6290
1/4	.7854	.0490	1/4	16.4934	21.6475
3/8	1.1781	.1104	3/8	16.8861	22.6907
1/2	1.5708	.1963	1/2	17.2788	23.7583
5/8	1.9635	.3068	5/8	17.6715	24.8505
3/4	2.3562	.4417	3/4	18.0642	25.9672
7/8	2.7489	.6013	7/8	18.4569	27.1085
1 *in.*	3.1416	.7854	6 *in.*	18.8496	28.2744
1/8	3.5343	.9940	1/8	19.2423	29.4647
1/4	3.9270	1.2271	1/4	19.6350	30.6796
3/8	4.3197	1.4848	3/8	20.0277	31.9192
1/2	4.7124	1.7671	1/2	20.4204	33.1831
5/8	5.1051	2.0739	5/8	20.8131	34.4717
3/4	5.4978	2.4052	3/4	21.2058	35.7847
7/8	5.8905	2.7611	7/8	21.5985	37.1224
2 *in.*	6.2832	3.1416	7 *in.*	21.9912	38.4846
1/8	6.6759	3.5465	1/8	22.3839	39.8713
1/4	7.0686	3.9760	1/4	22.7766	41.2825
3/8	7.4613	4.4302	3/8	23.1693	42.7184
1/2	7.8540	4.9087	1/2	23.5620	44.1787
5/8	8.2467	5.4119	5/8	23.9547	45.6636
3/4	8.6394	5.9395	3/4	24.3474	47.1730
7/8	9.0321	6.4918	7/8	24.7401	48.7070
3 *in.*	9.4248	7.0686	8 *in.*	25.1328	50.2656
1/8	9.8175	7.6699	1/8	25.5255	51.8486
1/4	10.2102	8.2957	1/4	25.9182	53.4562
3/8	10.6029	8.9462	3/8	26.3109	55.0885
1/2	10.9956	9.6211	1/2	26.7036	56.7451
5/8	11.3883	10.3206	5/8	27.0963	58.4264
3/4	11.7810	11.0446	3/4	27.4890	60.1321
7/8	12.1737	11.7932	7/8	27.8817	61.8625
4 *in.*	12.5664	12.5664	9 *in.*	28.2744	63.6174
1/8	12.9591	13.3640	1/8	28.6671	65.3968
1/4	13.3518	14.1862	1/4	29.0598	67.2007
3/8	13.7445	15.0331	3/8	29.4525	69.0293
1/2	14.1372	15.9043	1/2	29.8452	70.8823
5/8	14.5299	16.8001	5/8	30.2379	72.7599
3/4	14.9226	17.7205	3/4	30.6306	74.6620
7/8	15.3153	18.6655	7/8	31.0233	76.5887

CIRCLES, ADVANCING BY AN EIGHTH.

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
10 *in.*	31.4160	78.5400	16 *in.*	50.2656	201.0624
1/8	31.8087	80.5157	1/8	50.6583	204.2162
1/4	32.2014	82.5160	1/4	51.0510	207.3946
3/8	32.5941	84.5409	3/8	51.4437	210.5976
1/2	32.9868	86.5903	1/2	51.8364	213.8251
5/8	33.3795	88.6643	5/8	52.2291	217.0772
3/4	33.7722	90.7627	3/4	52.6218	220.3537
7/8	34.1649	92.8858	7/8	53.0145	223.6549
11 *in.*	34.5576	95.0334	17 *in.*	53.4072	226.9806
1/8	34.9503	97.2055	1/8	53.7999	230.3308
1/4	35.3430	99.4021	1/4	54.1926	233.7055
3/8	35.7357	101.6234	3/8	54.5853	237.1049
1/2	36.1284	103.8691	1/2	54.9780	240.5287
5/8	36.5211	106.1394	5/8	55.3707	243.9771
3/4	36.9138	108.4342	3/4	55.7634	247.4500
7/8	37.3065	110.7536	7/8	56.1561	250.9475
12 *in.*	37.6992	113.0976	18 *in.*	56.5488	254.4696
1/8	38.0919	115.4660	1/8	56.9415	258.0161
1/4	38.4846	117.8590	1/4	57.3342	261.5872
3/8	38.8773	120.2766	3/8	57.7269	265.1829
1/2	39.2700	122.7187	1/2	58.1196	268.8031
5/8	39.6627	125.1854	5/8	58.5123	272.4479
3/4	40.0554	127.6765	3/4	58.9050	276.1171
7/8	40.4481	130.1923	7/8	59.2977	279.8110
13 *in.*	40.8408	132.7326	19 *in.*	59.6904	283.5294
1/8	41.2335	135.2974	1/8	60.0831	287.2723
1/4	41.6262	137.8867	1/4	60.4758	291.0397
3/8	42.0189	140.5007	3/8	60.8685	294.8312
1/2	42.4116	143.1391	1/2	61.2612	298.6483
5/8	42.8043	145.8021	5/8	61.6539	302.4894
3/4	43.1970	148.4896	3/4	62.0466	306.3550
7/8	43.5897	151.2017	7/8	62.4393	310.2452
14 *in.*	43.9824	153.9384	20 *in.*	62.8320	314.1600
1/8	44.3751	156.6995	1/8	63.2247	318.0992
1/4	44.7678	159.4852	1/4	63.6174	322.0630
3/8	45.1605	162.2956	3/8	64.0101	326.0514
1/2	45.5532	165.1303	1/2	64.4028	330.0643
5/8	45.9459	167.9896	5/8	64.7955	334.1018
3/4	46.3386	170.8735	3/4	65.1882	338.1637
7/8	46.7313	173.7820	7/8	65.5809	342.2503
15 *in.*	47.1240	176.7150	21 *in.*	65.9736	346.3614
1/8	47.5167	179.6725	1/8	66.3663	350.4970
1/4	47.9094	182.6545	1/4	66.7590	354.6571
3/8	48.3021	185.6612	3/8	67.1517	358.8419
1/2	48.6948	188.6923	1/2	67.5444	363.0511
5/8	49.0875	191.7480	5/8	67.9371	367.2849
3/4	49.4802	194.8282	3/4	68.3298	371.5432
7/8	49.8729	197.9330	7/8	68.7225	375.8261

Diam.	Circum.	Area.	Diam.	Circum.	Area.
22 *in.*	69.1152	380.1336	28 *in.*	87.9648	615.7536
1/8	69.5079	384.4655	1/8	88.3575	621.2636
1/4	69.9006	388.8220	1/4	88.7502	626.7982
3/8	70.2933	393.2031	3/8	89.1429	632.3574
1/2	70.6860	397.6087	1/2	89.5356	637.9411
5/8	71.0787	402.0388	5/8	89.9283	643.5494
3/4	71.4714	406.4935	3/4	90.3210	649.1821
7/8	71.8641	410.9728	7/8	90.7137	654.8395
23 *in.*	72.2568	415.4766	29 *in.*	91.1064	660.5214
1/8	72.6495	420.0049	1/8	91.4991	666.2278
1/4	73.0422	424.5577	1/4	91.8918	671.9587
3/8	73.4349	429.1352	3/8	92.2845	677.7143
1/2	73.8276	433.7371	1/2	92.6772	683.4943
5/8	74.2203	438.3636	5/8	93.0699	689.2989
3/4	74.6130	443.0146	3/4	93.4626	695.1280
7/8	75.0057	447.6992	7/8	93.8553	700.9817
24 *in.*	75.3984	452.3904	30 *in.*	94.2480	706.8600
1/8	75.7911	457.1150	1/8	94.6407	712.7627
1/4	76.1838	461.8642	1/4	95.0334	718.6900
3/8	76.5765	466.6380	3/8	95.4261	724.6419
1/2	76.9692	471.4363	1/2	95.8188	730.6183
5/8	77.3619	476.2592	5/8	96.2115	736.6193
3/4	77.7546	481.1065	3/4	96.6042	742.6447
7/8	78.1473	485.9785	7/8	96.9969	748.6948
25 *in.*	78.5400	490.8750	31 *in.*	97.3896	754.7694
1/8	78.9327	495.7960	1/8	97.7823	760.8685
1/4	79.3254	500.7415	1/4	98.1750	766.9921
3/8	79.7181	505.7117	3/8	98.5677	773.1404
1/2	80.1108	510.7063	1/2	98.9604	779.3131
5/8	80.5035	515.7255	5/8	99.3531	785.5104
3/4	80.8962	520.7692	3/4	99.7458	791.7322
7/8	81.2889	525.8375	7/8	100.1385	797.9786
26 *in.*	81.6816	530.9304	32 *in.*	100.5312	804.2496
1/8	82.0743	536.0477	1/8	100.9239	810.5450
1/4	82.4670	541.1896	1/4	101.3166	816.8650
3/8	82.8597	546.3561	3/8	101.7093	823.2096
1/2	83.2524	551.5471	1/2	102.1020	829.5787
5/8	83.6451	556.7627	5/8	102.4947	835.9724
3/4	84.0378	562.0027	3/4	102.8874	842.3905
7/8	84.4305	567.2674	7/8	103.2801	848.8333
27 *in.*	84.8232	572.5566	33 *in.*	103.6728	855.3006
1/8	85.2159	577.8703	1/8	104.0655	861.7924
1/4	85.6086	583.2085	1/4	104.4582	868.3087
3/8	86.0013	588.5714	3/8	104.8509	874.8497
1/2	86.3940	593.9587	1/2	105.2436	881.4151
5/8	86.7867	599.3706	5/8	105.6363	888.0051
3/4	87.1794	604.8070	3/4	106.0290	894.6196
7/8	87.5721	610.2680	7/8	106.4217	901.2587

Diam.	Circum.	Area.	Diam.	Circum.	Area.
34 *in.*	106.8144	907.9224	40 *in.*	125.6640	1256.6400
1/8	107.2071	914.6105	1/8	126.0567	1264.5062
1/4	107.5998	921.3232	1/4	126.4494	1272.3970
3/8	107.9925	928.0605	3/8	126.8421	1280.3124
1/2	108.3852	934.8223	1/2	127.2348	1288.2523
5/8	108.7779	941.6087	5/8	127.6275	1296.2168
3/4	109.1706	948.4195	3/4	128.0202	1304.2057
7/8	109.5633	955.2550	7/8	128.4129	1312.2193
35 *in.*	109.9560	962.1150	41 *in.*	128.8056	1320.2574
1/8	110.3487	968.9995	1/8	129.1983	1328.3200
1/4	110.7414	975.9085	1/4	129.5910	1336.4071
3/8	111.1341	982.8422	3/8	129.9837	1344.5189
1/2	111.5268	989.8003	1/2	130.3764	1352.6551
5/8	111.9195	996.7830	5/8	130.7691	1360.8159
3/4	112.3122	1003.7902	3/4	131.1618	1369.0012
7/8	112.7049	1010.8220	7/8	131.5545	1377.2111
36 *in.*	113.0977	1017.8784	42 *in.*	131.9472	1385.4456
1/8	113.4903	1024.9592	1/8	132.3399	1393.7045
1/4	113.8830	1032.0646	1/4	132.7326	1401.9880
3/8	114.2757	1039.1946	3/8	133.1253	1410.2961
1/2	114.6684	1046.3491	1/2	133.5180	1418.6287
5/8	115.0611	1053.5281	5/8	133.9107	1426.9859
3/4	115.4538	1060.7317	3/4	134.3034	1435.3675
7/8	115.8465	1067.9599	7/8	134.6961	1443.7738
37 *in.*	116.2392	1075.2126	43 *in.*	135.0888	1452.2046
1/8	116.6319	1082.4898	1/8	135.4815	1460.6599
1/4	117.0246	1089.7915	1/4	135.8742	1469.1397
3/8	117.4173	1097.1179	3/8	136.2669	1477.6342
1/2	117.8100	1104.4687	1/2	136.6596	1486.1731
5/8	118.2027	1111.8441	5/8	137.0523	1494.7266
3/4	118.5954	1119.2440	3/4	137.4450	1503.3046
7/8	118.9881	1126.6685	7/8	137.8377	1511.9072
38 *in.*	119.3808	1134.1176	44 *in.*	138.2304	1520.5344
1/8	119.7735	1141.5911	1/8	138.6231	1529.1860
1/4	120.1662	1149.0892	1/4	139.0158	1537.8622
3/8	120.5589	1156.6119	3/8	139.4085	1546.5530
1/2	120.9516	1164.1591	1/2	139.8012	1555.2883
5/8	121.3443	1171.7309	5/8	140.1939	1564.0382
3/4	121.7370	1179.3271	3/4	140.5866	1572.8125
7/8	122.1297	1186.9480	7/8	140.9793	1581.6115
39 *in.*	122.5224	1194.5934	45 *in.*	141.3720	1590.4350
1/8	122.9151	1202.2633	1/8	141.7647	1599.2830
1/4	123.3078	1209.9577	1/4	142.1574	1608.1555
3/8	123.7005	1217.6768	3/8	142.5505	1617.0427
1/2	124.0932	1225.4203	1/2	142.9428	1625.9743
5/8	124.4859	1233.1884	5/8	143.3355	1634.9205
3/4	124.8786	1240.9810	3/4	143.7282	1643.8912
7/8	125.2713	1248.7982	7/8	144.1209	1652.8865

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
46 *in.*	144.5136	1661.9064	52 *in.*	163.3632	2123.7216
1/8	144.9063	1670.9507	1/8	163 7559	2133.9440
1/4	145.2990	1680.0196	1/4	164.1486	2144.1910
3/8	145.6917	1689.1031	3/8	164.5413	2154.4626
1/2	146.0844	1698.2311	1/2	164.9340	2164.7587
5/8	146.4771	1707.3737	5/8	165.3267	2175.0794
3/4	146.8698	1716.5407	3/4	165.7194	2185.4245
7/8	147.2625	1725.7324	7/8	166.1121	2195.7943
47 *in.*	147.6552	1734.9486	53 *in.*	166.5048	2206.1886
1/8	148.0479	1744.1893	1/8	166.8975	2216.6074
1/4	148.4406	1753.4545	1/4	167.2902	2227.0507
3/8	148.8333	1762.7344	3/8	167.6829	2237.5187
1/2	149.2260	1772.0587	1/2	168.0756	2248.0111
5/8	149.6187	1781.3976	5/8	168.4683	2258.5281
3/4	150.0114	1790.7610	3/4	168.8610	2269.0696
7/8	150.4041	1800.1490	7/8	169.2537	2279.6357
48 *in.*	150.7968	1809.5616	54 *in.*	169.6464	2290.2264
1/8	151.1895	1818.9986	1/8	170.0391	2300.8415
1/4	151.5822	1828.4602	1/4	170.4318	2311.4812
3/8	151.9749	1837.9364	3/8	170.8245	2322.1455
1/2	152.3676	1847.4571	1/2	171.2172	2332.8343
5/8	152.7603	1856.9924	5/8	171.6099	2343.5477
3/4	153.1530	1866.5521	3/4	172.0026	2354.2855
7/8	153.5457	1876.1365	7/8	172.3953	2365.0480
49 *in.*	153.9384	1885.7454	55 *in.*	172.7880	2375 8350
1/8	154.3311	1895.3788	1/8	173.1807	2386.6465
1/4	154.7238	1905.0367	1/4	173.5734	2397.4825
3/8	155.1165	1914.7093	3/8	173.9661	2408.3432
1/2	155.5092	1924.4263	1/2	174.3588	2419.2283
5/8	155.9019	1934.1579	5/8	174.7515	2430.1830
3/4	156.2946	1943.9140	3/4	175.1442	2441.0722
7/8	156.6873	1953.6947	7/8	175.5369	2452.0310
50 *in.*	157.0800	1963.5000	56 *in.*	175.9296	2463.0144
1/8	157.4727	1973.3297	1/8	176.3223	2474.0222
1/4	157.8654	1983.1840	1/4	176.7150	2485.0546
3/8	158.2581	1993.0529	3/8	177.1077	2496.1116
1/2	158.6508	2002.9663	1/2	177.5004	2507.1931
5/8	159.0435	2012.8943	5/8	177.8931	2518.2992
3/4	159.4362	2022.8467	3/4	178.2858	2529.4297
7/8	159.8289	2032.8238	7/8	178.6785	2540.5849
51 *in.*	160.2216	2042.8254	57 *in.*	179.0712	2551.7646
1/8	160.6143	2052.8515	1/8	179.4639	2562.9688
1/4	161.0070	2062.9021	1/4	179.8566	2574.1975
3/8	161.3997	2072.9674	3/8	180.2493	2585.4509
1/2	161.7924	2083.0771	1/2	180.6420	2596.7287
5/8	162.1851	2093.2014	5/8	181.0347	2608.0311
3/4	162.5778	2103.3502	3/4	181.4274	2619.3580
7/8	162.9705	2113.5236	7/8	181.8201	2630.7095

Diam.	Circum.	Area.	Diam.	Circum.	Area.
58 *in.*	182.2128	2642.0856	64 *in.*	201.0624	3216.9984
1/8	182.6055	2653.4861	1/8	201.4551	3229.5770
1/4	182.9982	2664.9112	1/4	201.8478	3242.1782
3/8	183.3909	2676.3609	3/8	202.2405	3254.8080
1/2	183.7836	2687.8351	1/2	202.6332	3267.4603
5/8	184.1763	2699.3338	5/8	203.0259	3280.1372
3/4	184.5690	2710.8571	3/4	203.4186	3292.8385
7/8	184.9617	2722.4050	7/8	203.8113	3305.5645
59 *in.*	185.3544	2733.9774	65 *in.*	204.2040	3318.3150
1/8	185.7471	2745.5743	1/8	204.5967	3331.0900
1/4	186.1398	2757.1957	1/4	204.9894	3343.8875
3/8	186.5325	2768.8418	3/8	205.3821	3356.7137
1/2	186.9252	2780.5123	1/2	205.7748	3369.5623
5/8	187.3179	2792.2074	5/8	206.1675	3382.4355
3/4	187.7106	2803.9270	3/4	206.5602	3395.3332
7/8	188.1033	2815.6712	7/8	206.9529	3408.2555
60 *in.*	188.4960	2827.4400	66 *in.*	207.3456	3421.2024
1/8	188.8887	2839.2332	1/8	207.7383	3434.1737
1/4	189.2814	2851.0510	1/4	208.1310	3447.1676
3/8	189.6741	2862.8934	3/8	208.5237	3460.1901
1/2	190.0668	2874.7603	1/2	208.9164	3473.2351
5/8	190.4595	2886.6517	5/8	209.3091	3486.3047
3/4	190.8522	2898.5677	3/4	209.7018	3499.3987
7/8	191.2449	2910.5083	7/8	210.0945	3512.5174
61 *in.*	191.6376	2922.4734	67 *in.*	210.4872	3525.6606
1/8	192.0303	2934.4630	1/8	210.8799	3538.8283
1/4	192.4230	2946.4771	1/4	211.2726	3552.0185
3/8	192.8157	2958.5159	3/8	211.6653	3565.2374
1/2	193.2084	2970.5791	1/2	212.0580	3578.4787
5/8	193.6011	2982.6669	5/8	212.4507	3591.7446
3/4	193.9938	2994.7792	3/4	212.8434	3605.0350
7/8	194.3865	3006.9161	7/8	213.2361	3618.3500
62 *in.*	194.7792	3019.0776	68 *in.*	213.6288	3631.6896
1/8	195.1719	3031.2635	1/8	214.0215	3645.0536
1/4	195.5646	3043.4740	1/4	214.4142	3658.4402
3/8	195.9573	3055.7091	3/8	214.8069	3671.8554
1/2	196.3500	3067.9687	1/2	215.1996	3685.2931
5/8	196.7427	3080.2529	5/8	215.5923	3698.7554
3/4	197.1354	3092.5615	3/4	215.9850	3712.2421
7/8	197.5281	3104.8948	7/8	216.3777	3725.7535
63 *in.*	197.9208	3117.2526	69 *in.*	216.7704	3739.2894
1/8	198.3135	3129.6349	1/8	217.1631	3752.8498
1/4	198.7062	3142.0417	1/4	217.5558	3766.4327
3/8	199.0989	3154.4732	3/8	217.9485	3780.0443
1/2	199.4916	3166.9291	1/2	218.3412	3793.6783
5/8	199.8843	3179.4096	5/8	218.7339	3807.3369
3/4	200.2770	3191.9146	3/4	219.1266	3821.0200
7/8	200.6697	3204.4442	7/8	219.5193	3834.7277

Diam.	Circum.	Area.	Diam.	Circum.	Area.
70 *in.*	219.9120	3848.4600	76 *in.*	238.7616	4536.4704
1/8	220.3047	3862.2167	1/8	239.1543	4551.4023
1/4	220.6974	3875.9960	1/4	239.5470	4566.3626
3/8	221.0901	3889.8039	3/8	239.9397	4581.3486
1/2	221.4828	3903.6343	1/2	240.3324	4596.3571
5/8	221.8755	3917.4893	5/8	240.7251	4611.3902
3/4	222.2682	3931.3687	3/4	241.1178	4626.4477
7/8	222.6609	3945.2728	7/8	241.5105	4641.5299
71 *in.*	223.0536	3959.2014	77 *in.*	241.9032	4656.6366
1/8	223.4463	3973.1545	1/8	242.2959	4671.7678
1/4	223.8390	3987.1301	1/4	242.6866	4686.9215
3/8	224.2317	4001.1344	3/8	243.0813	4702.1039
1/2	224.6244	4015.1611	1/2	243.4740	4717.3087
5/8	225.0171	4029.2124	5/8	243.8667	4732.5381
3/4	225.4098	4043.2882	3/4	244.2594	4747.7920
7/8	225.8025	4057.3886	7/8	244.6521	4763.0705
72 *in.*	226.1952	4071.5136	78 *in.*	245.0448	4778.3736
1/8	226.5879	4085.6631	1/8	245.4375	4793.7012
1/4	226.9806	4099.8350	1/4	245.8302	4809.0512
3/8	227.3733	4114.0356	3/8	246.2229	4824.4299
1/2	227.7660	4128.2587	1/2	246.6156	4839.8311
5/8	228.1587	4142.5064	5/8	247.0083	4855.2568
3/4	228.5514	4156.7785	3/4	247.4010	4870.7071
7/8	228.9441	4171.0753	7/8	247.7937	4886.1820
73 *in.*	229.3368	4185.3966	79 *in.*	248.1864	4901.6814
1/8	229.7295	4199.7424	1/8	248.5791	4917.2053
1/4	230.1222	4214.1107	1/4	248.9718	4932.7517
3/8	230.5149	4228.5077	3/8	249.3645	4948.3268
1/2	230.9076	4242.9271	1/2	249.7572	4963.9243
5/8	231.3003	4257.3711	5/8	250.1499	4979.5456
3/4	231.6930	4271.8396	3/4	250.5426	4995.1930
7/8	232.0857	4286.3327	7/8	250.9353	5010.8642
74 *in.*	232.4784	4300.8504	80 *in.*	251.3280	5026.5600
1/8	232.8711	4315.3926	1/8	251.7207	5042.2803
1/4	233.2638	4329.9572	1/4	252.1134	5058.0230
3/8	233.6565	4344.5505	3/8	252.5061	5073.7944
1/2	234.0492	4359.1663	1/2	252.8988	5089.5883
5/8	234.4419	4373.8067	5/8	253.2915	5105.4060
3/4	234.8346	4388.4715	3/4	253.6842	5121.2497
7/8	235.2273	4403.1610	7/8	254.0769	5137.1173
75 *in.*	235.6200	4417.8750	81 *in.*	254.4696	5153.0094
1/8	236.0127	4432.6135	1/8	254.8623	5168.9260
1/4	236.4054	4447.3745	1/4	255.2550	5184.8651
3/8	236.7981	4462.1642	3/8	255.6477	5200.8329
1/2	237.1908	4476.9763	1/2	256.0404	5216.8231
5/8	237.5835	4491.8130	5/8	256.4331	5232.8371
3/4	237.9762	4506.6742	3/4	256.8258	5248.8772
7/8	238.3689	4521.5600	7/8	257.2185	5264.9411

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
82 *in.*	257.6112	5281.0296	88 *in.*	276.4608	6082.1376
1/8	258.0039	5297.1426	1/8	276.8535	6099.4287
1/4	258.3866	5313.2780	1/4	277.2462	6116.7422
3/8	258.7993	5329.4421	3/8	277.6389	6134.0844
1/2	259.1820	5345.6287	1/2	278.0316	6151.4491
5/8	259.5747	5361.8391	5/8	278.4243	6168.8376
3/4	259.9674	5378.0755	3/4	278.8170	6186.2521
7/8	260.3601	5394.3358	7/8	279.2097	6203.6905
83 *in.*	260.7528	5410.6206	89 *in.*	279.6024	6221.1534
1/8	261.1455	5426.9299	1/8	279.9951	6238.6408
1/4	261.5382	5443.2617	1/4	280.3878	6256.1507
3/8	261.9309	5459.6222	3/8	280.7805	6273.6893
1/2	262.3236	5476.0051	1/2	281.1732	6291.2503
5/8	262.7163	5492.4118	5/8	281.5659	6308.8351
3/4	263.1090	5508.8446	3/4	281.9586	6326.4460
7/8	263.5017	5525.3012	7/8	282.3513	6344.0807
84 *in.*	263.8944	5541.7824	90 *in.*	282.7440	6361.7400
1/8	264.2871	5558.2881	1/8	283.1367	6379.4238
1/4	264.6798	5574.8162	1/4	283.5294	6397.1300
3/8	265.0725	5591.3730	3/8	283.9221	6414.8649
1/2	265.4652	5607.9523	1/2	284.3148	6432.6223
5/8	265.8579	5624.5554	5/8	284.7075	6450.4039
3/4	266.2506	5641.1845	3/4	285.1002	6468.2107
7/8	266.6433	5657.8357	7/8	285.4929	6486.0418
85 *in.*	267.0360	5674.5150	91 *in.*	285.8856	6503.8974
1/8	267.4287	5691.2170	1/8	286.2783	6521.7775
1/4	267.8214	5707.9415	1/4	286.6710	6539.6801
3/8	268.2141	5724.6947	3/8	287.0637	6557.6114
1/2	268.6068	5741.4703	1/2	287.4564	6575.5651
5/8	268.9995	5758.2697	5/8	287.8491	6593.5431
3/4	269.3922	5775.0952	3/4	288.2418	6611.5462
7/8	269.7849	5791.9445	7/8	288.6345	6629.5736
86 *in.*	270.1776	5808.8184	92 *in.*	289.0272	6647.6258
1/8	270.5703	5825.7168	1/8	289.4199	6665.7021
1/4	270.9630	5842.6376	1/4	289.8126	6683.8010
3/8	271.3557	5859.5871	3/8	290.2053	6701.9286
1/2	271.7484	5876.5591	1/2	290.5980	6720.0787
5/8	272.1411	5893.5549	5/8	290.9907	6738.2530
3/4	272.5338	5910.5767	3/4	291.3834	6756.4525
7/8	272.9265	5927.6224	7/8	291.7761	6774.6763
87 *in.*	273.3192	5944.6926	93 *in.*	292.1688	6792.9248
1/8	273.7119	5961.7873	1/8	292.5615	6811.1974
1/4	274.1046	5978.9045	1/4	292.9542	6829.4927
3/8	274.4973	5996.0504	3/8	293.3469	6847.8167
1/2	274.8900	6013.2187	1/2	293.7396	6866.1631
5/8	275.2827	6030.4108	5/8	294.1323	6884.5338
3/4	275.6754	6047.6290	3/4	294.5250	6902.9296
7/8	276.0681	6064.8710	7/8	294.9177	6921.3497

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
94 *in.*	295.3104	6939.7946	97 *in.*	304.7352	7389.8288
1/8	295.7031	6958.2636	1/8	305.1279	7408.8868
1/4	296.0958	6976.7552	1/4	305.5206	7427.9675
3/8	296.4885	6995.2755	3/8	305.9133	7447.0769
1/2	296.8812	7013.8183	1/2	306.3060	7466.2087
5/8	297.2739	7032.3853	5/8	306.6987	7485.3648
3/4	297.6666	7050.9775	3/4	307.0914	7504.5460
7/8	298.0593	7069·5940	7/8	307.4841	7523.7515
95 *in.*	298.4520	7088.2352	98 *in.*	307.8768	7542.9818
1/8	298.8447	7106.9005	1/8	308.2695	7562.2362
1/4	299.2374	7125.5885	1/4	308.6622	7581.5132
3/8	299.6301	7144.3052	3/8	309.0549	7600.8189
1/2	300.0228	7163.0443	1/2	309.4476	7620.1471
5/8	300.4155	7181.8077	5/8	309.8403	7639.4995
3/4	300.8082	7200.5962	3/4	310.2230	7658.8771
7/8	301.2009	7219.4090	7/8	310.6257	7678.2790
96 *in.*	301.5936	7238.2466	99 *in.*	311.0184	7697.7056
1/8	301.9863	7257.1083	1/8	311.4111	7717.1563
1/4	302.3790	7275.9926	1/4	311.8038	7736.6297
3/8	302.7717	7294.9056	3/8	312.1965	7756.1318
1/2	303.1644	7313.8411	1/2	312.5892	7775.6563
5/8	303.5571	7332.8008	5/8	312.9819	7795.2051
3/4	303.9498	7351.7857	3/4	313.3746	7814.7790
7/8	304.3425	7370.7949	7/8	313.7673	7834.3772
			100 *in.*	314.1600	7854.0000

TABLE X,

Containing the circumferences and areas of circles from 1 *to* 50 *feet, and advancing by an inch.*

Diam.	Circum.	Area.	Diam.	Circum.	Area.
1 *ft.*	3.1416	.7854	4 *ft.*	12.5664	12.5664
1	3.4034	.9217	1	12.8282	13.0952
2	3.6652	1.0690	2	13.0900	13.6353
3	3.9270	1.2271	3	13.3518	14.1862
4	4.1888	1.3962	4	13.6136	14.7479
5	4.4506	1.5761	5	13.8754	15.3206
6	4.7124	1.7671	6	14.1372	15.9043
7	4.9742	1.9689	7	14.3990	16.4986
8	5.2360	2.1816	8	14.6608	17.1041
9	5.4978	2.4052	9	14.9226	17.7205
10	5.7596	2.6398	10	15.1844	18.3476
11	6.0214	2.8852	11	15.4462	18.9858
2 *ft.*	6.2832	3.1416	5 *ft.*	15.7080	19.6350
1	6.5450	3.4087	1	15.9698	20.2947
2	6.8068	3.6869	2	16.2316	20.9656
3	7.0686	3.9760	3	16.4934	21.6475
4	7.3304	4.2760	4	16.7552	22.3400
5	7.5922	4.5869	5	17.0170	23.0437
6	7.8540	4.9087	6	17.2788	23.7583
7	8.1158	5.2413	7	17.5406	24.4835
8	8.3776	5.5850	8	17.8024	25.2199
9	8.6394	5.9395	9	18.0642	25.9672
10	8.9012	6.3049	10	18.3260	26.7251
11	9.1630	6.6813	11	18.5878	27.4943
3 *ft.*	9.4248	7.0686	6 *ft.*	18.8496	28.2744
1	9.6866	7.4666	1	19.1114	29.0649
2	9.9484	7.8757	2	19.3732	29.8668
3	10.2102	8.2957	3	19.6350	30.6796
4	10.4720	8.7265	4	19.8968	31.5029
5	10.7338	9.1683	5	20.1586	32.3376
6	10.9956	9.6211	6	20.4204	33.1831
7	11.2574	10.0846	7	20.6822	34.0391
8	11.5192	10.5591	8	20.9440	34.9065
9	11.7810	11.0446	9	21.2058	35.7847
10	12.0428	11.5409	10	21.4676	36.6735
11	12.3046	12.0481	11	21.7294	37.5736

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
7 *ft.*	21.9912	38.4846	11 *ft.*	34.5576	95.0334
1	22.2530	39.4060	1	34.8194	96.4783
2	22.5148	40.3388	2	35.0812	97.9347
3	22.7766	41.2825	3	35.3430	99.4021
4	23.0384	42.2367	4	35.6048	100.8797
5	23.3002	43.2022	5	35.8666	102.3689
6	23.5620	44.1787	6	36.1284	103.8691
7	23.8238	45.1656	7	36.3902	105.3794
8	24.0856	46.1638	8	36.6520	106.9013
9	24.3474	47.1730	9	36.9138	108.4342
10	24.6092	48.1926	10	37.1756	109.9772
11	24.8710	49.2236	11	37.4374	111.5319
8 *ft.*	25.1328	50.2656	12 *ft.*	37.6992	113.0976
1	25.3946	51.3178	1	37.9610	114.6732
2	25.6564	52.3816	2	38.2228	116.2607
3	25.9182	53.4562	3	38.4846	117.8590
4	26.1800	54.5412	4	38.7464	119.4674
5	26.4418	55.6377	5	39.0082	121.0876
6	26.7036	56.7451	6	39.2700	122.7187
7	26.9654	57.8628	7	39.5318	124.3598
8	27.2272	58.9920	8	39.7936	126.0127
9	27.4890	60.1321	9	40.0554	127.6765
10	27.7508	61.2826	10	40.3172	129.3504
11	28.0126	62.4445	11	40.5790	131.0360
9 *ft.*	28.2744	63.6174	13 *ft.*	40.8408	132.7326
1	28.5362	64.8006	1	41.1026	134.4391
2	28.7980	65.9951	2	41.3644	136.1574
3	29.0598	67.2007	3	41.6262	137.8867
4	29.3216	68.4166	4	41.8880	139.6260
5	29.5834	69.6440	5	42.1498	141.3771
6	29.8452	70.8823	6	42.4116	143.1391
7	30.1070	72.1309	7	42.6734	144.9111
8	30.3688	73.3910	8	42.9352	146.6949
9	30.6306	74.6620	9	43.1970	148.4896
10	30.8924	75.9433	10	43.4588	150.2943
11	31.1542	77.2362	11	43.7206	152.1109
10 *ft.*	31.4160	78.5400	14 *ft.*	43.9824	153.9384
1	31.6778	79.8540	1	44.2442	155.7758
2	31.9396	81.1795	2	44.5060	157.6250
3	32.2014	82.5160	3	44.7678	159.4852
4	32.4632	83.8627	4	45.0296	161.3553
5	32.7250	85.2211	5	45.2914	163.2373
6	32.9868	86.5903	6	45.5532	165.1303
7	33.2486	87.9697	7	45.8150	167.0331
8	33.5104	89.3608	8	46.0768	168.9479
9	33.7722	90.7627	9	46.3386	170.8735
10	34.0340	92.1749	10	46.6004	172.8091
11	34.2958	93.5986	11	46.8622	174.7565

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
15 *ft.*	47.1240	176.7150	19 *ft.*	59.6904	283.5294
1	47.3858	178.6832	1	59.9522	286.0210
2	47.6476	180.6634	2	60.2140	288.5249
3	47.9094	182.6545	3	60.4758	291.0397
4	48.1712	184.6555	4	60.7376	293.5641
5	48.4330	186.6684	5	60.9994	296.1007
6	48.6948	188.6923	6	61.2612	298.6483
7	48.9566	190.7260	7	61.5230	301.2054
8	49.2184	192.7716	8	61.7848	303.7747
9	49.4802	194.8282	9	62.0466	306.3550
10	49.7420	196.8946	10	62.3084	308.9448
11	50.0038	198.9730	11	62.5702	311.5469
16 *ft.*	50.2656	201.0624	20 *ft.*	62.8320	314.1600
1	50.5274	203.1615	1	63.0938	316.7824
2	50.7892	205.2726	2	63.3556	319.4173
3	51.0510	207.3946	3	63.6174	322.0630
4	51.3128	209.5264	4	63.8792	324.7182
5	51.5746	211.6703	5	64.1410	327.3858
6	51.8364	213.8251	6	64.4028	330.0643
7	52.0982	215.9896	7	64.6646	332.7522
8	52.3600	218.1662	8	64.9264	335.4525
9	52.6218	220.3537	9	65.1882	338.1637
10	52.8836	222.5510	10	65.4500	340.8844
11	53.1454	224.7603	11	65.7118	343.6174
17 *ft.*	53.4072	226.9806	21 *ft.*	65.9736	346.3614
1	53.6690	229.2105	1	66.2354	349.1147
2	53.9308	231.4525	2	66.4972	351.8804
3	54.1926	233.7055	3	66.7590	354.6571
4	54.4544	235.9682	4	67.0208	357.4432
5	54.7162	238.2430	5	67.2826	360.2417
6	54.9780	240.5287	6	67.5444	363.0511
7	55.2398	242.8241	7	67.8062	365.8698
8	55.5016	245.1316	8	68.0680	368.7011
9	55.7634	247.4500	9	68.3298	371.5432
10	56.0252	249.7781	10	68.5916	374.3947
11	56.2870	252.1184	11	68.8534	377.2587
18 *ft.*	56.5488	254.4696	22 *ft.*	69.1152	380.1336
1	56.8106	256.8303	1	69.3770	383.0177
2	57.0724	259.2033	2	69.6388	385.9144
3	57.3342	261.5872	3	69.9006	388.8220
4	57.5960	263.9807	4	70.1624	391.7389
5	57.8578	266.3864	5	70.4242	394.6683
6	58.1196	268.8031	6	70.6860	397.6087
7	58.3814	271.2293	7	70.9478	400.5583
8	58.6432	273.6678	8	71.2096	403.5204
9	58.9050	276.1171	9	71.4714	406.4935
10	59.1668	278.5761	10	71.7332	409.4759
11	59.4286	281.0472	11	71.9950	412.4707

Diam.	Circum.	Area.	Diam.	Circum.	Area.
23 *ft.*	72.2568	415.4766	27 *ft.*	84.8232	572.5566
1	72.5186	418.4915	1	85.0850	576.0949
2	72.7804	421.5192	2	85.3468	579.6463
3	73.0422	424.5577	3	85.6086	583.2085
4	73.3040	427.6055	4	85.8704	586.7796
5	73.5658	430.6658	5	86.1322	590.3637
6	73.8276	433.7371	6	86.3940	593.9587
7	74.0894	436.8175	7	86.6558	597.5625
8	74.3512	439.9106	8	86.9176	601.1793
9	74.6130	443.0146	9	87.1794	604.8070
10	74.8748	446.1278	10	87.4412	608.4436
11	75.1366	449.2536	11	87.7030	612.0931
24 *ft.*	75.3984	452.3904	28 *ft.*	87.9648	615.7536
1	75.6602	455.5362	1	88.2266	619.4228
2	75.9220	458.6948	2	88.4884	623.1050
3	76.1838	461.8642	3	88.7502	626.7982
4	76.4456	465.0428	4	89.0120	630.5002
5	76.7074	468.2341	5	89.2738	634.2152
6	76.9692	471.4363	6	89.5356	637.9411
7	77.2310	474.6476	7	89.7974	641.6758
8	77.4928	477.8716	8	90.0592	645.4235
9	77.7546	481.1065	9	90.3210	649.1821
10	78.0164	484.3506	10	90.5828	652.9495
11	78.2782	487.6073	11	90.8446	656.7300
25 *ft.*	78.5400	490.8750	29 *ft.*	91.1064	660.5214
1	78.8018	494.1516	1	91.3682	664.3214
2	79.0636	497.4411	2	91.6300	668.1346
3	79.3254	500.7415	3	91.8918	671.9587
4	79.5872	504.0510	4	92.1536	675.7915
5	79.8490	507.3732	5	92.4154	679.6375
6	80.1108	510.7063	6	92.6772	683.4943
7	80.3726	514.0484	7	92.9390	687.3598
8	80.6344	517.4034	8	93.2008	691.2385
9	80.8962	520.7692	9	93.4626	695.1280
10	81.1580	524.1441	10	93.7244	699.0263
11	81.4198	527.5318	11	93.9862	702.9377
26 *ft.*	81.6816	530.9304	30 *ft.*	94.2480	706.8600
1	81.9434	534.3379	1	94.5098	710.7909
2	82.2052	537.7583	2	94.7716	714.7350
3	82.4670	541.1896	3	95.0334	718.6900
4	82.7288	544.6299	4	95.2952	722.6537
5	82.9906	548.0830	5	95.5570	726.6305
6	83.2524	551.5471	6	95.8186	730.6183
7	83.5142	555.0201	7	96.0806	734.6147
8	83.7760	558.5059	8	96.3424	738.6242
9	84.0378	562.0027	9	96.6042	742.6447
10	84.2996	565.5084	10	96.8660	746.6738
11	84.5614	569.0270	11	97.1278	750.7161

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
39 *ft.*	122.5224	1194.5934	43 *ft.*	135.0888	1452.2046
1	122.7842	1199.7195	1	135.3506	1457.8365
2	123.0460	1204.8244	2	135.6124	1463.4827
3	123.3078	1209.9577	3	135.8742	1469.1397
4	123.5696	1215.0990	4	136.1360	1474.8044
5	123.8314	1220.2542	5	136.3978	1480.4833
6	124.0932	1225.4203	6	136.6596	1486.1731
7	124.3550	1230.5943	7	136.9214	1491.8705
8	124.6168	1235 7822	8	137.1832	1497.5821
9	124.8786	1240.9810	9	137.4450	1503.3046
10	125.1404	1246.1878	10	137.7068	1509.0348
11	125.4022	1251.4084	11	137.9686	1514.7791
40 *ft.*	125.6640	1256.6400	44 *ft.*	138.2304	1520.5344
1	125.9258	1261.8794	1	138.4922	1526.2971
2	126.1876	1267.1327	2	138.7540	1532.0742
3	126.4494	1272.3970	3	139.0158	1537.8622
4	126.7112	1277.6692	4	139.2776	1543.6578
5	126.9730	1282.9553	5	139.5394	1549.4676
6	127.2348	1288.2523	6	139.8012	1555.2883
7	127.4966	1293.5572	7	140.0630	1561.1165
8	127.7584	1298.8760	8	140.3248	1566.9591
9	128.0202	1304.2057	9	140.5866	1572.8125
10	128.2820	1309.5433	10	140.8484	1578.6735
11	128.5438	1314.8949	11	141.1102	1584.5488
41 *ft.*	128.8056	1320.2574	45 *ft.*	141.3720	1590.4350
1	129.0674	1325.6276	1	141.6338	1596.3286
2	129.3292	1331.0119	2	141.8956	1602.2366
3	129.5910	1336.4071	3	142.1574	1608.1555
4	129.8528	1341.8101	4	142.4192	1614.0819
5	130.1146	1347.2271	5	142.6810	1620.0226
6	130.3764	1352.6551	6	142.9428	1625.9743
7	130.6382	1358.0908	7	143.2046	1631.9334
8	130.9000	1363.5406	8	143.4664	1637.9068
9	131.1618	1369.0012	9	143.7282	1643.8912
10	131.4236	1374.4697	10	143.9900	1649.8831
11	131.6854	1379.9521	11	144.2518	1655.8892
42 *ft.*	131.9472	1385 4456	46 *ft.*	144.5136	1661.9064
1	132.2090	1390.2467	1	144.7754	1667.9308
2	132.4708	1396.4619	2	145.0372	1673.9698
3	132.7326	1401.9880	3	145.2990	1680.0196
4	132.9944	1407.5219	4	145.5608	1686.0769
5	133.2562	1413.0698	5	145.8226	1692.1485
6	133.5180	1418.6287	6	146.0844	1698.2311
7	133.7798	1424.1952	7	146.3462	1704.3210
8	134.0416	1429.7759	8	146.6080	1710.4254
9	134.3034	1435.3675	9	146.8698	1716.5407
10	134.5652	1440.9668	10	147.1316	1722.6634
11	134.8270	1446.5802	11	147.3934	1728.8005

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
31 *ft.*	97.3896	754.7694	35 *ft.*	109.9560	962.1150
1	97.6514	758.8311	1	110.2178	966.7001
2	97.9132	762.9062	2	110.4796	971.2989
3	98.1750	766.9921	3	110.7414	975.9085
4	98.4368	771.0866	4	111.0032	980.5264
5	98.6986	775.1944	5	111.2650	985.1579
6	98.9604	779.3131	6	111.5268	989.8003
7	99.2222	783.4403	7	111.7886	994.4509
8	99.4840	787.5808	8	112.0504	999.1151
9	99.7458	791.7322	9	112.3122	1003.7902
10	100.0076	795.8922	10	112.5740	1008.4736
11	100.2694	800.0654	11	112.8358	1013.1705
32 *ft.*	100.5312	804.2496	36 *ft.*	113.0976	1017.8784
1	100.7930	808.4422	1	113.3594	1022.5944
2	101.0548	812.6481	2	113.6212	1027.3240
3	101.3166	816.8650	3	113.8830	1032.0646
4	101.5784	821.0904	4	114.1448	1036.8134
5	101.8402	825.3291	5	114.4066	1041.5758
6	102.1020	829.5787	6	114.6684	1046.3491
7	102.3638	833.8368	7	114.9302	1051.1306
8	102.6256	838.1082	8	115.1920	1055.9257
9	102.8874	842.3905	9	115.4538	1060.7317
10	103.1492	846.6813	10	115.7756	1065.5459
11	103.4110	850.9855	11	115.9774	1070.3738
33 *ft.*	103.6728	855.3006	37 *ft.*	116.2392	1075.2126
1	103.9346	859.6240	1	116.5010	1080.0594
2	104.1964	863.9609	2	116.7628	1084.9201
3	104.4582	868.3087	3	117.0246	1089.7915
4	104.7200	872.6649	4	117.2864	1094.6711
5	104.9818	877.0346	5	117.5482	1099.5644
6	105.2436	881.4151	6	117.8100	1104.4687
7	105.5054	885.8040	7	118.0718	1109.3810
8	105.7672	890.2064	8	118.3336	1114.3071
9	106.0290	894.6196	9	118.5954	1119.2440
10	106.2908	899.0413	10	118.8572	1124.1891
11	106.5526	903.4763	11	119.1190	1129.1478
34 *ft.*	106.8144	907.9224	38 *ft.*	119.3808	1134.1176
1	107.0762	912.3767	1	119.6426	1139.0953
2	107.3380	916.8445	2	119.9044	1144.0868
3	107.5998	921.3232	3	120.1662	1149.0892
4	107.8616	925.8103	4	120.4280	1154.0997
5	108.1234	930.3108	5	120.6898	1159.1239
6	108.3852	934.8223	6	120.9516	1164.1591
7	108.6470	939.3421	7	121.2134	1169.2023
8	108.9088	943.8753	8	121.4752	1174.2592
9	109.1706	948.4195	9	121.7370	1179.3271
10	109.4324	952.9720	10	121.9988	1184.4030
11	109.6942	957.5380	11	122.2606	1189.4927

Diam.	Circum.	Area.	Diam.	Circum	Area.
47 *ft.*	147.6552	1734.9486	48 7	152.6294	1853.8087
1	147.9170	1741.1039	8	152.8912	1860.1750
2	148.1788	1747.2738	9	153.1530	1866.5521
3	148.4406	1753.4545	10	153.4148	1872.9365
4	148.7024	1759.6426	11	153.6766	1879.3355
5	148.9642	1765.8452	49 *ft.*	153.9384	1885.7454
6	149.2260	1772.0587	1	154.2002	1892.1724
7	149.4878	1778.2795	2	154.4620	1898.5041
8	149.7496	1784.5148	3	154.7238	1905.0367
9	150.0114	1790.7610	4	154.9856	1911.4965
10	150.2732	1797.0145	5	155.2474	1917.9609
11	150.5350	1803.2826	6	155.5092	1924.4263
48 *ft.*	150.7968	1809.5616	7	155.7710	1930.9188
1	151.0586	1815.8477	8	156.0328	1937.3159
2	151.3204	1822.1485	9	156.2946	1943.9140
3	151.5822	1828.4602	10	156.5564	1950.4392
4	151.8440	1834.7791	11	156.8182	1956.9691
5	152.1058	1841.1127	50 *ft.*	157.0800	1963.5000
6	152.3676	1847.4571			

TABLE XI,

Containing the superficies and solid content of spheres, from 1 to 12, and advancing by a tenth.

Diam.	Superficies.	Solidity.	Diam.	Superficies.	Solidity.
1.0	3.1416	.5236	2.5	19.6350	8.1812
.1	3.8013	.6969	.6	21.2372	9.2027
.2	4.5239	.9047	.7	22.9022	10.3060
.3	5.3093	1.1503	.8	24.6300	11.4940
.4	6.1575	1.4367	.9	26.4208	12.7700
.5	7.0686	1.7671	3.0	28.2744	14.1372
.6	8.0424	2.1446	.1	30.1907	15.5985
.7	9.0792	2.5724	.2	32.1699	17.1573
.8	10.1787	3.0536	.3	34.2120	18.8166
.9	11.3411	3.5913	.4	36.3168	20.5795
2.0	12.5664	4.1888	.5	38.4846	22.4493
.1	13.8544	4.8490	.6	40.7151	24.4290
.2	15.2053	5.5752	.7	43.0085	26.5219
.3	16.6190	6.3706	.8	45.3647	28.7309
.4	18.0956	7.2382	.9	47.7837	31.0594

Diam.	*Superficies.*	*Solidity.*	*Diam.*	*Superficies.*	*Solidity.*
4.0	50.2656	33.5104	8.0	201.0624	268.0832
.1	52.8102	36.0870	.1	206.1203	278.2625
.2	55.4178	38.7924	.2	211.2411	288.6962
.3	58.0881	41.6298	.3	216.4248	299.3876
.4	60.8213	44.6023	.4	221.6712	310.3398
.5	63.6174	47.7130	.5	226.9806	321.5558
.6	66.4782	50.9651	.6	232.3527	333.0389
.7	69.3979	54.3617	.7	237.7877	344.7921
.8	72.3824	57.9059	.8	243.2855	356.8187
.9	75.4298	61.6010	.9	248.8461	369.1217
5.0	78.5400	65.4500	9.0	254.4696	381.7044
.1	81.7130	69.4560	.1	260.1558	394.5697
.2	84.9488	73.6223	.2	265.9130	407.7210
.3	88.2475	77.9519	.3	271.7169	421.1613
.4	91.6090	82.4481	.4	277.5917	434.8937
.5	95.0334	87.1139	.5	283.5294	448.9215
.6	98.5205	91.9525	.6	289.5298	463.2477
.7	102.0705	96.9670	.7	295.5931	477.7755
.8	105.6834	102.1606	.8	301.7192	492.8081
.9	109.3590	107.5364	.9	307.9082	508.0485
6.0	113.0976	113.0976	10.0	314.1600	523.6000
.1	116.8989	118.8472	.1	320.4746	539.4656
.2	120.7631	124.7885	.2	326.8520	555.6485
.3	124.6901	130.9246	.3	333.2923	572.1518
.4	128.6799	137.2585	.4	339.7954	588.9784
.5	132.7326	143.7936	.5	346.3614	606.1324
.6	136.8480	150.5329	.6	352.9901	623.6159
.7	141.0264	157.4795	.7	359.6817	641.4325
.8	145.2675	164.6365	.8	366.4362	659.5852
.9	149.5715	172.0073	.9	373.2534	678.0771
7.0	153.9384	179.5948	11.0	380.1336	696.9116
.1	158.3680	187.4021	.1	387.0765	716.0915
.2	162.8605	195.4326	.2	394.0823	735.6200
.3	167.4158	203.6893	.8	401.1509	755.5008
.4	172.0340	212.1752	.4	408.2823	775.7364
.5	176.7150	220.8937	.5	415.4766	796.3301
.6	181.4588	229.8478	.6	422.7336	817.2851
.7	186.2654	239.0511	.7	430.0536	838.6045
.8	191.1349	248.4754	.8	437.4363	860.2915
.9	196.0672	258.1552	.9	444.8819	882.3492
			12.0	452.3904	904.7808

TABLE XII,

Containing the squares, cubes, superficies, and solid content of spheres, from ½ inch to 12 inches, advancing by an eighth.

Diam.	*Squares.*	*Cubes.*	*Superficies.*	*Solidity.*
½	.25	.125	.7854	.0654
⅝	.390625	.244140625	1.2271	.1278
¾	.5625	.421875	1.7671	.2208
⅞	.765625	.669921875	2.4052	.3507
1 *in.*	1	1	3.1416	.5236
⅛	1.265625	1.423818125	3.9760	.7455
¼	1.5625	1.953125	4.9087	1.0226
⅜	1.890625	2.599609375	5.9395	1.3611
½	2.25	3.375	7.0686	1.7671
⅝	2.640625	4.291015625	8.2957	2.2467
¾	3.0625	5.359375	9.6211	2.8061
⅞	3.515625	6.591796875	11.0446	3.4514
2 *in.*	4	8	12.5664	4.1888
⅛	4.515625	9.595703125	14.1862	5.0243
¼	5.0625	11.390625	15.9043	5.9640
⅜	5.640625	13.39648375	17.7205	7.0143
½	6.25	15.625	19.6350	8.1812
⅝	6.890625	18.087890625	21.6475	9.4708
¾	7.5625	20.796875	23.7583	10.8892
⅞	8.265625	23.763671875	25.9672	12.4426
3 *in.*	9	27	28.2744	14.1372
⅛	9.765625	30.517578125	30.6796	15.9790
¼	10.5625	34.328125	33.1831	17.9742
⅜	11.390625	38.443359375	35.7847	20.1289
½	12.25	42.875	38.4846	22.4493
⅝	13.140625	47.634765625	41.2825	24.9415
¾	14.0625	52.734375	44.1787	27.6117
⅞	15.015625	58.185546875	47.1730	30.4659
4 *in.*	16	64	50.2656	33.5104
⅛	17.015625	70.189453125	53.4562	36.7511
¼	18.0625	76.765625	56.7451	40.1944
⅜	19.140625	83.740234375	60.1321	43.8463
½	20.25	91.125	63.6174	47.7127
⅝	21.390625	98.931640625	67.2007	51.8006
¾	22.5625	107.171875	70.8823	56.1151
⅞	23.765625	115.857421875	74.6620	60.6629
5 *in.*	25	125	78.5400	65.4500
⅛	26.265625	134.611328125	82.5160	70.4824
¼	27.5625	144.703125	86.5903	75.7664
⅜	28.890625	155.287109375	90.7627	81.3083
½	30.25	166.375	95.0334	87.1139
⅝	31.640625	177.978515625	99.4021	93.1875
¾	33.0625	190.109375	103.8691	99.5412
⅞	34.515625	202.779296875	108.4342	106.1754

Diam.	*Squares.*	*Cubes.*	*Superficies.*	*Solidity.*
6 *in.*	36	216	113.0976	113.0976
1/8	37.515625	229.783203115	117.8590	120.3139
1/4	39.0625	244.140625	122.7187	127.8320
3/8	40.640625	259.083984375	127.6765	135.6563
1/2	42.25	274.625	132.7326	143.7936
5/8	43.890625	290.775390625	137.8867	152.2499
3/4	45.5625	307.546875	143.1391	161.0315
7/8	47.265625	324.951171875	148.4896	170.1682
7 *in.*	49	343	153.9384	179.5948
1/8	50·765625	361.704078125	159.4852	189.3882
1/4	52·5625	381.078125	165.1303	199.5325
3/8	54·390625	401.130859375	170.8735	210.0331
1/2	56·25	421.875	176.7150	220.8937
5/8	58.140625	443.322265625	182.6545	232.1235
3/4	60.0625	465.484375	188.6923	243.7276
7/8	62.015625	488.373046875	194.8282	255.7121
8 *in.*	64	512	201.0624	268.0832
1/8	66.015625	536.376953125	207.3946	280.8469
1/4	68.0625	561.515625	213.8251	294.0095
3/8	70.140625	587.427734375	220.3537	307.5771
1/2	72.25	614.125	226.9806	321.5553
5/8	74.390625	641.619140625	233.7055	335.9517
3/4	76.5625	669.921875	240.5287	350.7710
7/8	78.765625	699.044921875	247.4500	366.0199
9 *in.*	81	729	254.4696	381.7017
1/8	83·265625	759.798828125	261.5872	397.8306
1/4	85·5625	791.453125	268.8031	414.4048
3/8	87·890625	823.974609375	276.1171	431.4361
1/2	90·25	857.375	283.5294	448.9215
5/8	92·640625	891.666015625	291.0397	466.8763
3/4	95·0625	926.859375	298.6483	485.3035
7/8	97·515625	962.966796875	306.3550	504.2094
10 *in.*	100	1000	314.1600	523.6000
1/8	102.515625	1037.970703125	322.0630	543.4814
1/4	105.0625	1076.890625	330.0643	563.8603
3/8	107.640625	1116.771448375	338.1637	584.7415
1/2	110.25	1157.625	346.3614	606.1318
5/8	112.890625	1199.462890625	354.6571	628.0387
3/4	115.5625	1242.296875	363.0511	650.4666
7/8	118.265625	1286.138671875	371.5432	673.4222
11 *in.*	121	1331	380.1336	696.9116
1/8	123.765625	1376.892578125	388.8220	720.9409
1/4	126.5625	1423.828125	397.6087	745.5004
3/8	129.390625	1471.818359375	406.4935	770.6440
1/2	132.25	1520.875	415.4766	796.3301
5/8	135.140625	1571.009765625	424.5576	822.5807
3/4	138.0625	1622.234375	433.7371	849.4035
7/8	141.015625	1674.560546875	443.0146	876.7999
12 *in.*	144	1728	452.3904	904.7808

A Table containing the price of metals, or other materials, by the ton, cwt., quarter, or lb.

Per ton. £ s. d.	Per cwt. s. d.	Per qrtr. s. d.	℔ lb
2 6 8	2 4	0 7	¼
2 10 0	2 6	0 7½	..
2 15 0	2 9	0 8¼	..
3 0 0	3 0	0 9	..
3 5 0	3 3	0 9¾	..
3 10 0	3 6	0 10½	..
3 15 0	3 9	0 11¼	..
4 0 0	4 0	1 0	..
4 5 0	4 3	1 0¾	..
4 10 0	4 6	1 1½	..
4 13 4	4 8	1 2	½
4 15 0	4 9	1 2¼	..
5 0 0	5 0	1 3	..
5 5 0	5 3	1 3¾	..
5 10 0	5 6	1 4½	..
5 15 0	5 9	1 5¼	..
6 0 0	6 0	1 6	..
6 5 0	6 3	1 6¾	..
6 10 0	6 6	1 7½	..
6 15 0	6 9	1 8¼	.
7 0 0	7 0	1 9	¾
7 5 0	7 3	1 9¾	..
7 10 0	7 6	1 10½	..
7 15 0	7 9	1 11¼	.
8 0 0	8 0	2 0	..
8 5 0	8 3	2 0¾	..
8 10 0	8 6	2 1½	..
8 15 0	8 9	2 2¼	..
9 0 0	9 0	2 3	..
9 5 0	9 3	2 3¾	..
9 6 8	9 4	4	1
9 10 0	9 6	2 4½	..
9 15 0	9 9	2 5¼	.
10 0 0	10 0	2 6	..
10 5 0	10 3	2 6¾	..
10 10 0	10 6	2 7½	..
10 15 0	10 9	2 8¼	..
11 0 0	11 0	2 9	..
11 5 0	11 3	2 9¾	..
11 10 0	11 6	2 10½	..
11 13 4	11 8	2 11	1¼
11 15 0	11 9	2 11¼	..
12 0 0	12 0	3 0	..
12 5 0	12 3	3 0¾	..
12 10 0	12 6	3 1½	..
12 15 0	12 9	3 2¼	..
13 0 0	13 0	3 3	..
13 5 0	13 3	3 3¾	..
13 10 0	13 6	3 4½	..
13 15 0	13 9	3 5¼	..
14 0 0	14 0	3 6	1½
14 5 0	14 3	3 6¾	

Per ton. £ s. d.	Per cwt. £ s. d.	Per qrtr. s. d.	℔ lb d.
14 10 0	0 14 6	7½	..
14 15 0	0 14 9	3 8¼	..
15 0 0	0 15 0	3 9	..
15 5 0	0 15 3	3 9¾	..
15 10 0	0 15 6	3 10½	..
15 15 0	0 15 9	3 11¼	..
16 0 0	0 16 0	4 0	..
16 5 0	0 16 3	4 0¾	..
16 6 8	0 16 4	4 1	1¾
16 10 0	0 16 6	4 1½	..
16 15 0	0 16 9	4 2¼	..
17 0 0	0 17 0	4 3	..
17 5 0	0 17 3	4 3¾	..
17 10 0	0 17 6	4 4½	..
17 15 0	0 17 9	4 5¼	..
18 0 0	0 18 0	4 6	..
18 5 0	0 18 3	4 6¾	..
18 10 0	0 18 6	4 7½	..
18 13 4	0 18 8	4 8	2
18 15 0	0 18 9	4 8¼	..
19 0 0	0 19 0	4 9	..
19 5 0	0 19 3	4 9¾	..
19 10 0	0 19 6	4 10½	..
19 15 0	0 19 9	4 11¼	..
20 0 0	1 0 0	5 0	..
20 10 0	1 0 6	5 1½	..
21 0 0	1 1 0	5 3	2¼
21 10 0	1 1 6	5 4½	..
22 0 0	1 2 0	5 6	..
22 10 0	1 2 6	5 7½	..
23 0 0	1 3 0	5 9	..
23 6 8	1 3 4	5 10	2½
23 10 0	1 3 6	5 10½	..
24 0 0	1 4 0	6 0	..
24 10 0	1 4 6	6 1½	..
25 0 0	1 5 0	6 3	..
25 10 0	1 5 6	6 4½	..
25 13 4	1 5 8	6 5	2¾
26 0 0	1 6 0	6 6	..
26 10 0	1 6 6	6 7½	..
27 0 0	1 7 0	6 9	..
27 10 0	1 7 6	6 10½	..
28 0 0	1 8 0	7 0	3
28 10 0	1 8 6	7 1½	..
29 0 0	1 9 0	7 3	..
29 10 0	1 9 6	7 4½	..
30 0 0	1 10 0	7 6	..
30 6 8	1 10 4	7 7	3¼
30 10 0	1 10 6	7 7½	..
31 0 0	1 11 0	7 9	..
31 10 0	1 11 6	7 10½	..
32 0 0	1 12 0	8 0	..

Per ton. £ s. d.	Per cwt. £ s. d.	Per qrtr. £ s. d.	℔ lb. d.
32 10 0	1 12 6	0 8 1½	..
32 13 4	1 12 8	0 8 2	3½
33 0 0	1 13 0	0 8 3	..
33 10 0	1 13 6	0 8 4½	..
34 0 0	1 14 0	0 8 6	.
34 10 0	1 14 6	0 8 7½	..
35 0 0	1 15 0	0 8 9	3¾
35 10 0	1 15 6	0 8 10½	..
36 0 0	1 16 0	0 9 0	..
36 10 0	1 16 6	0 9 1½	..
37 0 0	1 17 0	0 9 3	..
37 6 8	1 17 4	0 9 4	4
37 10 0	1 17 6	0 9 4½	..
38 0 0	1 18 0	0 9 6	..
38 10 0	1 18 6	0 9 7½	..
39 0 0	1 19 0	0 9 9	..
39 10 0	1 19 6	0 9 10½	..
39 13 4	1 19 8	0 9 11	4¼
40 0 0	2 0 0	0 10 0	..
40 10 0	2 0 6	0 10 1½	..
41 0 0	2 1 0	0 10 3	..
41 10 0	2 1 6	0 10 4½	..
42 0 0	2 2 0	0 10 6	4½
44 6 8	2 4 4	0 11 1	4¾
46 13 4	2 6 8	0 11 8	5
49 0 0	2 9 0	0 12 3	5¼
51 6 8	2 11 4	0 12 10	5½
53 13 4	2 13 8	0 13 5	5¾
56 0 0	2 16 0	0 14 0	6
58 6 8	2 18 4	0 14 7	6¼
60 13 4	3 0 8	0 15 2	6½
63 0 0	3 3 0	0 15 9	6¾
65 6 8	3 5 4	0 16 4	7
67 13 4	3 7 8	0 16 11	7¼
70 0 0	3 10 0	0 17 6	7½
72 6 8	3 12 4	0 18 1	7¾
74 13 4	3 14 8	0 18 8	8
77 0 0	3 17 0	0 19 3	8¼
79 6 8	3 19 4	0 19 10	8½
81 13 4	4 1 8	1 0 5	8¾
84 0 0	4 4 0	1 1 0	9
86 6 8	4 6 4	1 1 7	9¼
88 13 4	4 8 8	1 2 2	9½
91 0 0	4 11 0	1 2 9	9¾
93 6 8	4 13 4	1 3 4	10
95 13 4	4 15 8	1 3 11	10¼
98 0 0	4 18 0	1 4 6	10½
100 6 8	5 0 4	1 5 1	10¾
102 13 4	5 2 8	1 5 8	11
107 6 8	5 7 4	1 6 10	11½
112 0 0	5 12 0	1 8 0	12

A Table for calculating interest.

	3 per cent.			3½ per cent.			4 per cent.			4½ per cent.			5 per cent.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
2,000,000	164	7	8.05	191	15	7.40	219	3	6.74	246	11	6.08	273	19	5.42
1,000,000	82	3	10.03	95	17	9.70	109	11	9.37	123	5	9.04	136	19	8.71
900,000	73	19	5.42	86	6	0.33	98	12	7.23	110	19	2.14	123	5	9.04
800,000	65	15	0.82	76	14	2.96	87	13	5.10	98	12	7.23	109	11	9.37
700,000	57	10	8.22	67	2	5.59	76	14	2.96	86	6	0.33	95	17	9.70
600,000	49	6	3.62	57	10	8.22	65	15	0.82	73	19	5.42	82	3	10.03
500,000	41	1	11.01	47	18	10.85	54	15	10.69	61	12	10.52	68	9	10.36
400,000	32	17	6.41	38	7	1.48	43	16	8.55	49	6	3.62	54	15	10.68
300,000	24	13	1.81	28	15	4.11	32	17	6.41	36	19	8.71	41	1	11.01
200,000	16	8	9.21	19	3	6.74	21	18	4.27	24	13	1.81	27	7	11.34
100,000	8	4	4.60	9	11	9.37	10	19	2.14	12	6	6.90	13	13	11.67
90,000	7	7	11.34	8	12	7.23	9	17	3.12	11	1	11.01	12	6	6.90
80,000	6	11	6.08	7	13	5.10	8	15	4.11	9	17	3.12	10	19	2.14
70,000	5	15	0.82	6	14	2.96	7	13	5.10	8	12	7.23	9	11	9.37
60,000	4	18	7.56	5	15	0.82	6	11	6.08	7	7	11.34	8	4	4.60
50,000	4	2	2.30	4	15	10.68	5	9	7.07	6	3	3.45	6	16	11.84
40,000	3	5	9.04	3	16	8.55	4	7	8.05	4	18	7.56	5	9	7.07
30,000	2	9	3.78	2	17	6.41	3	5	9.04	3	13	11.67	4	2	2.30
20,000	1	12	10.52	1	18	4.27	2	3	10.03	2	9	3.78	2	14	9.53
10,000	0	16	5.26	..	19	2.14	1	1	11.01	1	4	7.89	1	7	4.77
9,000	..	14	9.53	..	17	3.12	..	19	8.71	1	2	2.30	1	4	7.89
8,000	..	13	1.81	..	15	4.11	..	17	6.41	..	19	8.71	1	1	11.01
7,000	..	11	6.08	..	13	5.10	..	15	4.11	..	17	3.12	..	19	2.14
6,000	..	9	10.36	..	11	6.08	..	13	1.81	..	14	9.53	..	16	5.26
5,000	..	8	2.63	..	9	7.07	..	10	11.51	..	12	3.94	..	13	8.38
4,000	..	6	6.90	..	7	8.05	..	8	9.20	..	9	10.36	..	10	11.51
3,000	..	4	11.18	..	5	9.04	..	6	6.90	..	7	4.77	..	8	2.63
2,000	..	3	3.45	..	3	10.03	..	4	4.60	..	4	11.18	..	5	5.75
1,000	..	1	7.73	..	1	11.01	..	2	2.30	..	2	5.59	..	2	8.88
900	..	1	5.75	..	1	8.71	..	1	11.67	..	2	2.63	..	2	5.59
800	..	1	3.78	..	1	6.41	..	1	9.04	..	1	11.67	..	2	2.30
700	..	1	1.81	..	1	4.11	..	1	6.41	..	1	8.71	..	1	11.01
600	..	..	11.84	..	1	1.81	..	1	3.78	..	1	5.75	..	1	7.73
500	..	..	9.86	..	..	11.51	..	1	1.15	..	1	2.79	..	1	4.44
400	..	..	7.89	..	..	9.21	..	..	10.52	..	..	11.84	..	1	1.15
300	..	..	5.92	..	..	6.90	..	..	7.89	..	..	8.88	..	..	9.86
200	..	..	3.95	..	..	4.60	..	..	5.26	..	..	5.92	..	..	6.58
100	..	..	1.97	..	..	2.30	..	..	2.63	..	..	2.96	..	..	3.29
90	..	..	1.78	..	..	2.07	..	..	2.37	..	..	2.66	..	..	2.96
80	..	..	1.58	..	..	1.84	..	..	2.10	..	..	2.37	..	..	2.63
70	..	..	1.38	..	..	1.61	..	..	1.84	..	..	2.07	..	..	2.30
60	..	..	1.18	..	..	1.38	..	..	1.58	..	..	1.78	..	..	1.97
50	..	..	0.99	..	..	1.15	..	..	1.32	..	..	1.48	..	..	1.64
40	..	..	0.79	..	..	.92	..	..	1.05	..	..	1.18	..	..	1.32
30	..	..	0.59	..	..	.69	..	..	.79	..	..	.89	..	..	1.00
20	..	..	0.39	..	..	.46	..	..	.55	..	..	.59	..	..	.66
10	..	..	0.20	..	..	.23	..	..	.26	..	..	.30	..	..	.35
9	..	..	0.18	..	..	.21	..	..	.24	..	..	.27	..	..	.30
8	..	..	0.16	..	..	.18	..	..	.21	..	..	.24	..	..	.26
7	..	..	0.14	..	..	.16	..	..	.18	..	..	.21	..	..	.23
6	..	..	0.12	..	..	.14	..	..	.16	..	..	.18	..	..	.20
5	..	..	0.10	..	..	.12	..	..	.13	..	..	.15	..	..	.16
4	..	..	0.08	..	..	.09	..	..	.11	..	..	.12	..	..	.13
3	..	..	0.06	..	..	.07	..	..	.08	..	..	.09	..	..	.10
2	..	..	0.04	..	..	.05	..	..	.05	..	..	.06	..	..	.07
1	..	..	0.02	..	..	.02	..	..	.03	..	..	.03	..	..	.03

NOTE.—For 2 per cent. take the half of 4, and 2½ per cent. the half of 5.

RULE.—Multiply the principle by the number of days, and take the interest corresponding to the product from the marginal column.

EXAMPLE.—Suppose £375 for 144 days, at 3 per cent.

375 × 144 = 54,000.

By table—50,000 =	£4	2	2.30
4,000 =	0	6	6.90
Interest..	£4	8	9.20

A Table of discount per cent.

	s.	d.		s.	d.
2½ per cent. is	0	6 per £	9 per cent. is	1	9½ per £
3 "	0	7¼	9½ "	1	10¾
3½ "	0	8½	10 "	2	0
4 "	0	9½	10½ "	2	1¼
4½ "	0	10¾	12½ "	2	6
5 "	1	0	15 "	3	0
5½ "	1	1¼	17½ "	3	7
6 "	1	2½	20 "	4	0
6½ "	1	3½	22½ "	4	6
7 "	1	5	25 "	5	0
7½ "	1	6	30 "	6	0
8 "	1	7	35 "	7	0
8½ "	1	8½	40 "	8	0

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